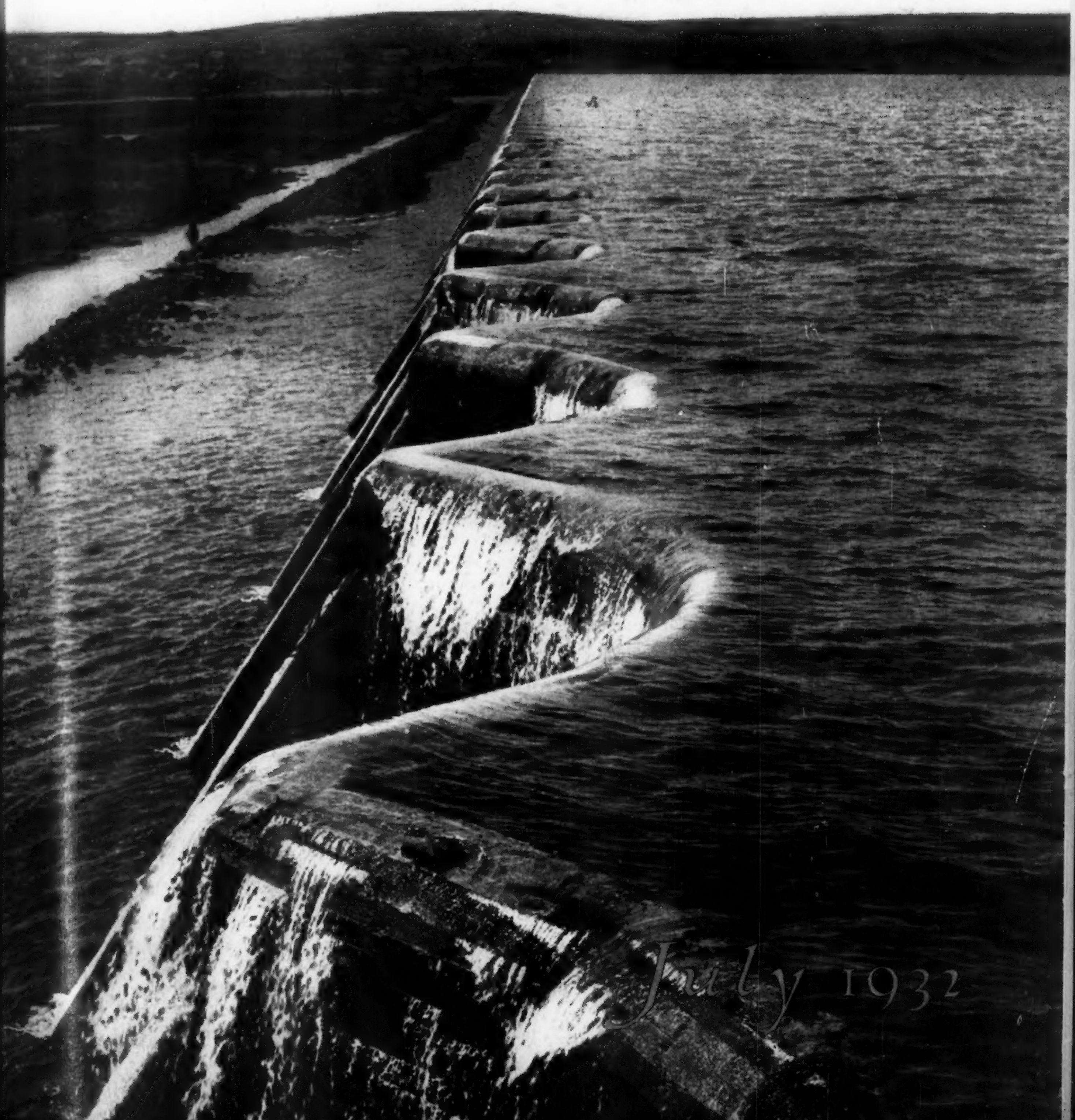
MECHANICAL ENGINEERING



MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 54 NUMBER 7

Contents for July, 1932

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of addresses must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B2, Par. 3). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921.

GROUP OF RUSSIAN CONSTRUCTION WORKERS, MAGNETOGORSK BLAST FURNACE

WHAT IT'S ALL ABOUT

A MUCH-QUOTED commentary on contemporary affairs that appeared in *Harper's Weekly* during the depression of 1857 speaks of Russia as a dark cloud on the horizon. For western peoples and for the civilizations of Mediterranean and Mesopotamian origin this cloud has always hung, mysterious and threatening, above their destinies. From it bolts of devastating lightning have struck periodically. From it have rained barbaric hordes of northern and eastern peoples caught up by some powerful centralizing force from the tundra, steppes, forests, and mountains of Asia and Eastern Europe into shapeless westward and southward moving masses of Huns, Alans, Slavs, Goths, Bulgars, Avars, Mongolians, Magyars, Tartars, and others that piled up against natural barriers until their very weight overcame further resistance. Before Troy burned, beyond the "clashing rocks," and the "friendless sea," the country north of the Black Sea was traditionally unfriendly to the Greeks, as Euripides reminds us in "Iphigenia in Tauris." In the sixth century B.C., Darius retreated from it after disastrous encounters with the Scythians. The great Roman Empire, ignorant of it as a potential menace, was content to recruit soldiers for the imperial legions from its untrained warriors. And when decadence and decay split up the Empire, descendants of these peoples from the East succeeded in many cases to its impoverished civilization.

OUT of the East, too, came the great Genghis Khan before whom fell the armies of Russia under the Grand Duke of Kief, bringing the Mongols to the shores of the Black Sea in the 13th century. More than two centuries later, Ivan the Great, Grand Duke of Moscow, threw off the Mongol yoke and by subjugating the ancient republic of Novgorod in the north, laid the foundations of the Russian Empire. With a government patterned after oriental despotism this great Empire grew in size and power until it threatened the peace of Western Europe and the civilized world. It alone, besides Great Britain, successfully withstood the aggression of Napoleon. Alexander II, at about the time the Civil War was raging in the United States, freed the Russian serfs and thus initiated a long series of partially successful but mostly thwarted attempts on the part of the people to attain a political freedom similar to that enjoyed by their western neighbors, but without the advantages of democratic traditions, closely knit communities, adequate transportation and communication facilities, education, freedom from the influence of a state religion, and a favorable geographical situation. At last, in the despair and confusion of the Great War, the Russian Empire suddenly disintegrated. Amid scenes of savage ruthlessness, aristocrats and bourgeois were massacred, exiled, dispossessed, and persecuted in the senseless fury that marked the revolution, and from it emerged that political anomaly, a Union of Soviet Socialist Republics, whose government is a dictatorship of the proletariat. Industrialization and modernization of this great country is now going forward in accordance with a national plan.

IT IS NOT our purpose to pass judgment on the Russian people or to criticize their political, social, and economic institutions. As a nation Russia is emerging, seriously handicapped, from a tremendous crisis into an industrialized world. She possesses a vast territory rich in natural resources, and a people accustomed to the rigors of a low standard of living and to hard physical labor. In the construction programs which are vital features of her economic plan, she has been forced to rely upon the engineers and technologists of other countries to supply the knowledge and experience without which great industrial and engineering works cannot be accomplished. Many of these men have come from the United States, bringing with them what is just as essential as strong backs and raw materials—engineering knowledge and abundant technological skill.

AS A LEADING article in this month's Mechanical Engineering we present a description of one of the greatest metallurgical projects the world has ever known, the construction of Magnetogorsk, written by the American engineer, William A. Haven, who was in charge of the work. From Mr. Haven's article we have taken for our cover picture a photograph of the multiple-arch dam across the Ural River, for which another American engineer, the late Gardner S. Williams, acted as consulting engineer, and which was constructed under the supervision of Mr. Haven's company. This dam, which is 3500 feet long and 35 feet high, forms a natural lake, on the shores of which the mining and steel-mill city of Magnetogorsk is now arising, a bit of modern machine civilization in the midst of frontier surroundings. The dam, Mr. Haven, tells us, was designed and constructed in five months.

It is more significant of what Magnetogorsk means than it is consistent with our usual practice that we have reproduced in these pages, usually reserved for portraits of individuals who have won honor and distinction, a group of the unnamed workers who helped to build Magnetogorsk. Mr. Haven reminds us that "the common labor is recruited from the primitive semi-Mongolian native tribes of that region—who are perfectly at home in tents and mud houses," representative of a nomadic life that stretches back beyond the days of the Great Khan to the threatening clouds that have always hung over central Asia and southern Europe.

IN SHARP contrast to the feverish activity that marks such construction as that at Magnetogorsk and other Soviet projects is the economic stagnation to be found today in the countries where industrialization was developed and where its greatest effects in raising the standard of living have been manifested.

TODAY in these countries the dead hand of business depression is laid upon trade and production. Millions of willing workers are idle, starvation and suffering exist side by side with overproduction in foods and manufactured commodities. Nations whose social and political institutions are based on the principles of democracy and individual initiative and responsibility are supporting great masses of those peoples out of the public treasury, and in the United States certain sober-minded men and elected representatives of the people are proceeding on the theory that the Federal Government owes every citizen a living. Over our democratic institutions hangs the cloud of socialization.

TO THIS state of affairs in another paper in this month's Mechanical Engineering, James D. Mooney, vice-president of General Motors Corporation in charge of Overseas Operations, and president, General Motors Export Company, gives his attention. He says: "The imagination of the world has been captured by the dramatic experiment of complete state socialism in Russia, and industrialists everywhere have been watching with excited interest the effects of the attempt at integrated industry. . . . The experiment seems to be coming off rather well. . . . Democracy, however, must commend itself to the industrial administrator, not only because a man's personal liberties are as important to him as his standard of living, but because . . . democracy . . . holds forth the best promise of raising the standard of living. . . . Democracy recognizes the natural instinct to acquire and own property. . . . Democracy believes that it is best for the group to allow a free play of economic forces and rely on the individual to make his own adjustment to these forces. Democracy does not offer the presumption of master minds. . . . Democracy offers industry a guarantee against stagnation."

LAST month we published a report by a committee of the American Engineering Council on the balancing of economic forces. Engineers prepared and wrote this report. It is significant of an inclination on the part of engineers to look on more than the technological phases of their profession and to interest themselves in line with Mr. Mooney's exclamation, "What a contribution engineering could make to a better codification and understanding of economic laws!"

To return to our first figure, therefore, let us remember that it is not the cloud on the horizon that shuts off light and warmth, but the one that lies between us and the sun. Ignorance, stupidity, social, economic, and political troubles in our own country provide the mists that darken the light of intelligence and reason. Our great hope for the future lies in the fact that that light of scientific inquiry is still shining.

RUSSIANS HAVE A PENCHANT FOR DOING BIG THINGS IN A BIG WAY—PUTTING UP ALMOST ALL OF A 175-FOOT STACK IN ONE LIFT

MAGNETOGORSK

Some Comments on the Design and Construction of a Mining and Metallurgical Plant for the U.S.S.R.

By WM. A. HAVEN[1]

MAGNETOGORSK is one of a small number of the industrial projects in Soviet Russia's Five-Year Plan that were almost entirely prepared in America. The word "project" as used here and as Russian engineers and officials commonly employ it, means design drawings, specifications for materials and equipment, estimates of construction and production costs, and a complete written explanation of building and operating processes.

The project for the Magnetogorsk mines and metallurgical plant was prepared by Arthur G. McKee & Company at their Cleveland, Ohio, headquarters during April, May, and June, 1930, on the basis of information brought to America by a commission of Russian engineers headed by V. Smolianinoff, manager of Magnetostroy, the Russian organization in charge of this undertaking. It covers the developments of an ore-mining and concentrating establishment of 25,000 tons daily feed capacity, eight batteries of by-product coke ovens each capable of producing approximately 1000 tons of coke per day, eight blast furnaces of 1000 tons daily rated capacity, two open-hearth and one bessemer steel producing departments having a total annual ingot capacity of 2,600,000 tons, and three blooming mills and nine finishing mills with a combined yearly output of 2,100,000 tons of rails, structural shapes, and merchant-mill products. Various large items of an auxiliary nature also had to be planned for, including a dam 1000 meters or five-eighths of a mile long, a 300,000-kw power house, pump houses, and maintenance and repair shops of all kinds.

SCOPE OF PROJECT UNUSUAL

The preparation of this project forms an interesting chapter in the annals of metallurgical engineering. The scope of the work, the time schedule of completion, and the remote location of the plant would alone take it out of the ordinary, and many other unusual features are to be noted. The original plan contemplated the making of all drawings and specifications in America, but on such a basis that the equipment could be purchased to the best advantage in any of the markets of the world, or, if possible, be secured within the U.S.S.R. Russian building materials had to be used to the greatest possible extent, a policy which required reinforced-concrete construction in many cases where structural steel would have simplified designs and speeded erection. For all steel structural work the use of Russian standard sections, which are not only quite different from ours but much more limited in variety and size, was a requisite. The Russian standards for strength of materials and their building codes and regulations had to be complied with. All designs were required to be dimensioned in metric measures as well as in feet and inches, and inscribed in the Russian and English languages.

DESIGN OF PLANT LARGELY MADE IN AMERICA

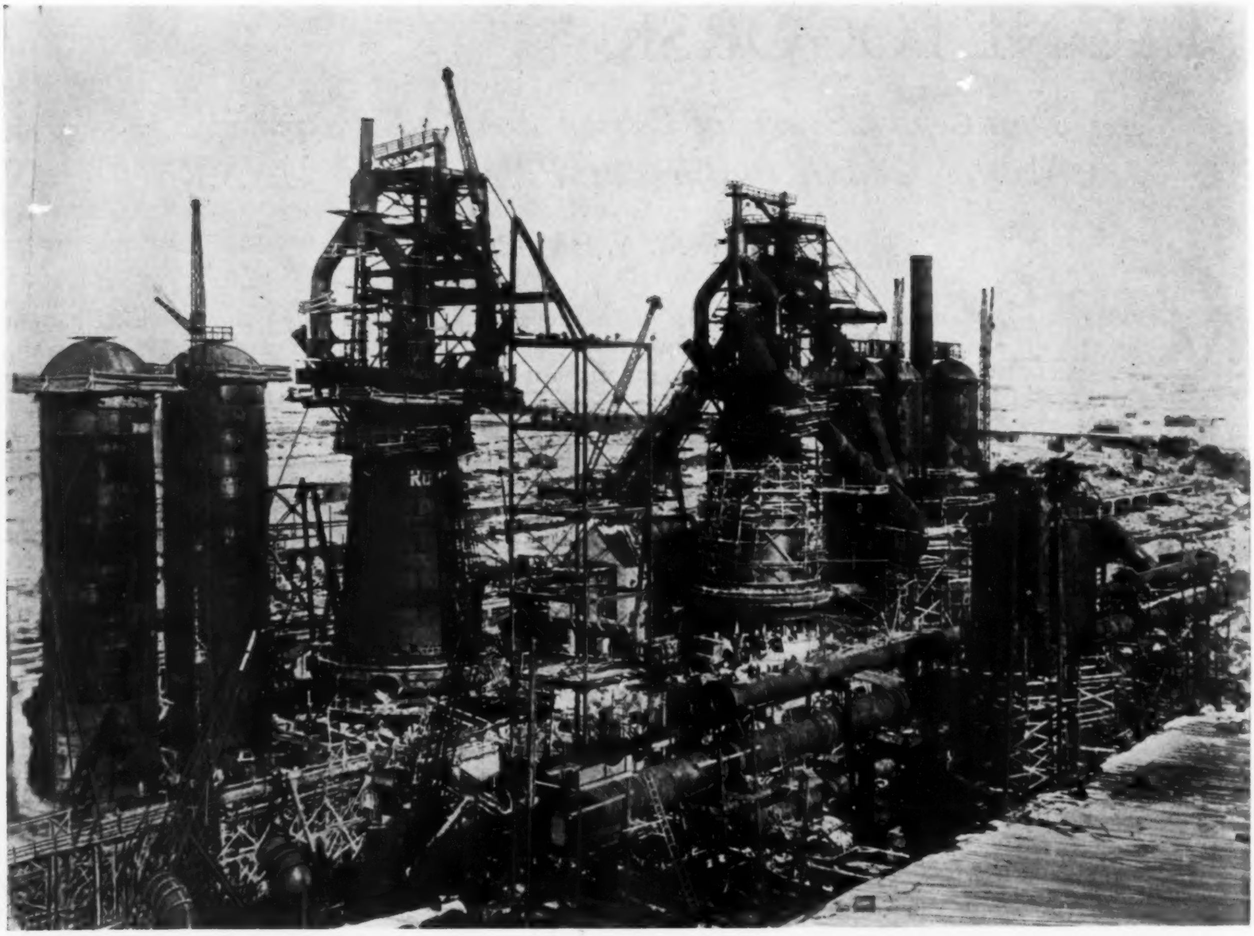
In general, however, the design of the plant and the specifications for its equipment were planned for, as specified in the contract between the Soviet government and the engineering firm, "in accordance with the best American practices." No trouble was experienced in getting the Russian commission which collaborated in the work in Cleveland, to approve of large production units or modern equipment. On the other hand, some difficulty was had in preventing the adoption of methods and equipment whose practicability had not been thoroughly demonstrated. Considering their ample supply of cheap labor, the obsession of the Russians for labor-saving processes and machinery is rather remarkable. At any rate the general plans for the Magnetogorsk metallurgical plant and mines as finally agreed upon and accepted represented a thoroughly up-to-date establishment, more so, perhaps, than any of the largest old plants in other countries.

The making of the final and detail drawings for Magnetogorsk required a force of many hundred draftsmen working at the McKee headquarters in Cleveland, for the Koppers Company in Pittsburgh, and for other firms in America to whom certain divisions of the work were assigned, for a period of about twenty months.

Some of the design work in connection with the open-hearth furnaces and rolling mills is still being carried on in the U.S.S.R. These divisions of the project were taken over by the Russian design organizations when only partially finished, largely because it was impossible to place orders for the mills with American firms. One unfortunate result of this procedure has been a serious delay in the construction of the steel-making and rolling departments. Coordinating design work when done by different organizations in the U.S.S.R. is a tremendously difficult task, and the backwardness of these divisions demonstrates clearly the advantages of unified or single responsibility.

During 1930 and 1931, construction work was under the guidance of McKee engineers stationed at Magneto-

[1] Vice-President, Arthur G. McKee & Co., Cleveland, Ohio.



MAGNETOGORSK BLAST FURNACES NOS. 1 AND 2 DURING CONSTRUCTION

gorsk. The first force of eleven men, which arrived at the plant site on June 1, 1930, had been furnished with preliminary drawings before leaving Cleveland, and this made it possible to start immediately with certain phases of the work, particularly excavation and the building of the dam. Other designs were then forwarded in ample time to keep fully employed as many workers as could be moved into and properly housed in this remote and isolated camp.

LIVING CONDITIONS AT MAGNETOGORSK

Some particulars concerning living conditions at Magnetogorsk may be of interest to American readers. The first McKee forces were of necessity stationed in log houses typical of that vicinity, and with the limited conveniences that such a primitive region could provide. Within a few months, however, a considerable number of small frame and stucco bungalows were erected and equipped in a manner that left but little to be desired in the way of housing. Two or three men were quartered in each apartment, which consisted of separate sleeping rooms, a joint living room, a kitchen with stove, and a combination bathroom and toilet. Even wood-burning hot-water heaters of the standard Russian manufacture were included. House heating was from a central plant, and a more or less constant supply of water was piped in from the Ural River.

The men, with the exception of a few who were accompanied by their wives, ate at a central restaurant or *Stolovia*. The food was simple and not always prepared in strict accordance with American tastes, but was at least ample in supply. In the summer-time the flies and lack of refrigeration were a problem, but on the whole the conditions were not so vastly different from construction-camp life in any other land. Certainly a sincere effort was made by the Russians to give the Americans living conditions that would approach American standards.

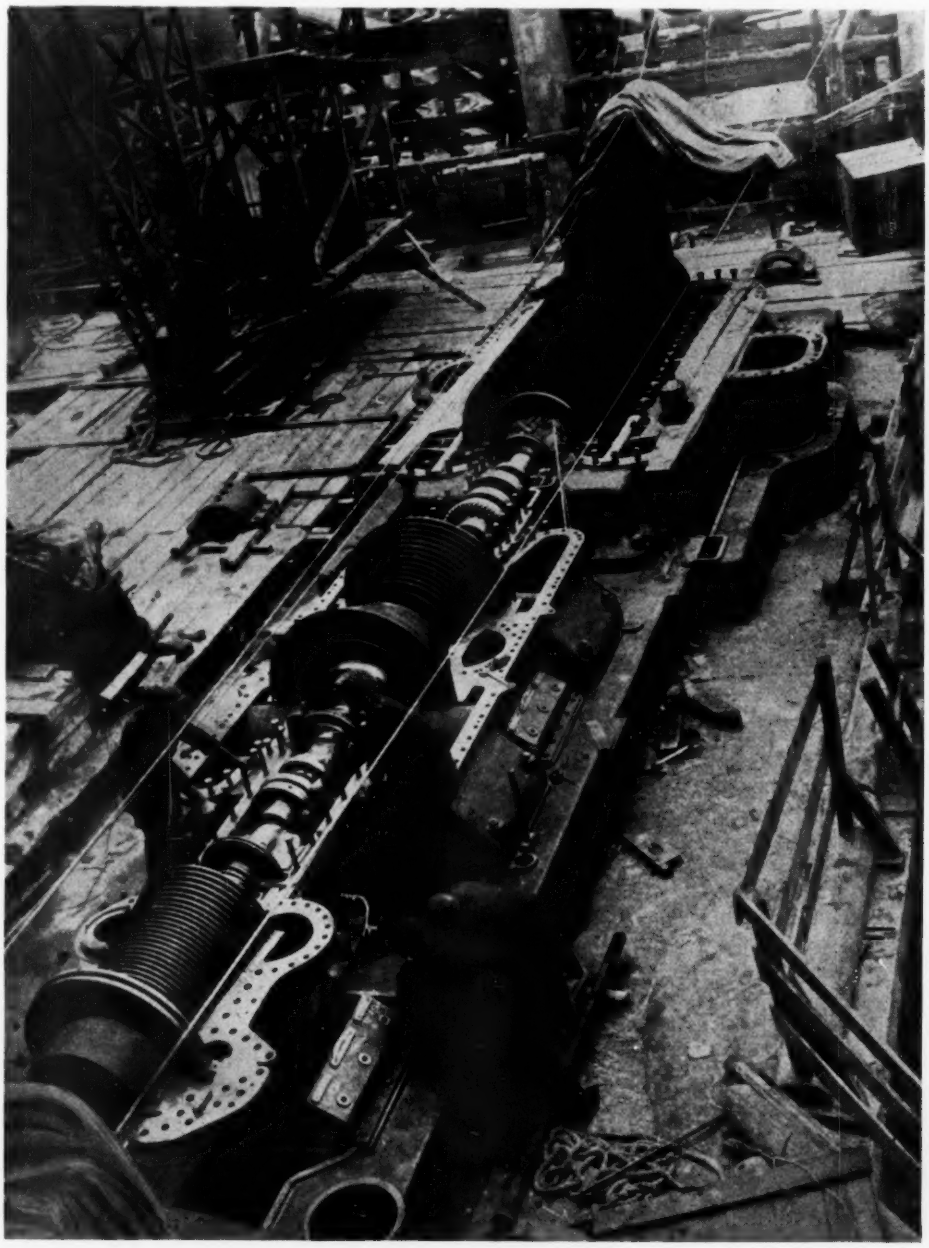
As great a quantity of American foods, tobacco, and household accessories as any individual might care to bring in was admitted freely, and a limited amount of such articles could be received by mail at a greatly reduced duty. Such a policy was not only helpful in getting satisfactory service from the Americans, but it also had an educational influence on the Russian workers and engineers. In such a remote district as Magnetogorsk, American wearing apparel, canned foods, household appliances, radios, cameras, and the like were a

permanent source of interest, and together with the importance which the Americans attached to good food, and to roomy, clean quarters and sanitary living conditions, these things gave to the Russians an opportunity to compare, in a way, American domestic life with their own.

In some cases the Russian engineers were provided with quarters identical with those of the Americans. Others were stationed in apartment hotels. The workers were housed in every conceivable type of dwelling, from tents to six-story brick apartments. The population of Magnetogorsk grew from 5000 to 150,000 in less than two years' time, so that building operations in the city itself formed not the least difficult part of the entire project, and the supply of houses has never been able to meet the demand. Much of the common labor of Magnetogorsk, however, is recruited from the primitive semi-Mongolian native tribes of that region, Bashkerians and Kirghiz, who are perfectly at home in tents or mud houses, and to these the warmly constructed and heated barracks probably seemed quite luxurious.

COMPLEXITIES OF SOVIET ORGANIZATIONS ENCOUNTERED BY AMERICAN ENGINEERS

In the building of the plant the duties imposed upon the American engineers were different from those which they would have encountered in any other part of the globe. The complexities of organization in a Soviet undertaking are certainly without counterpart elsewhere. Although the responsibility is nominally centered in the manager of the *Stroy*, or managing trust, it is actually more or less equally divided among the leaders of the trade unions and the local party secretary. Further confusion is introduced by the substantially independent nature of the national organizations to which special types of construction are delegated. There were at least a dozen of these organizations at Magnetogorsk, all huge trusts which were simultaneously carrying on similar work in other parts of the U.S.S.R. Over all these organizations brood the officers of the G.P.U., the political police. Furthermore, the Russian engineers and workers are encouraged to adopt an individualistic attitude toward their jobs and associates, and a high standard of discipline and teamwork is consequently almost unattainable.



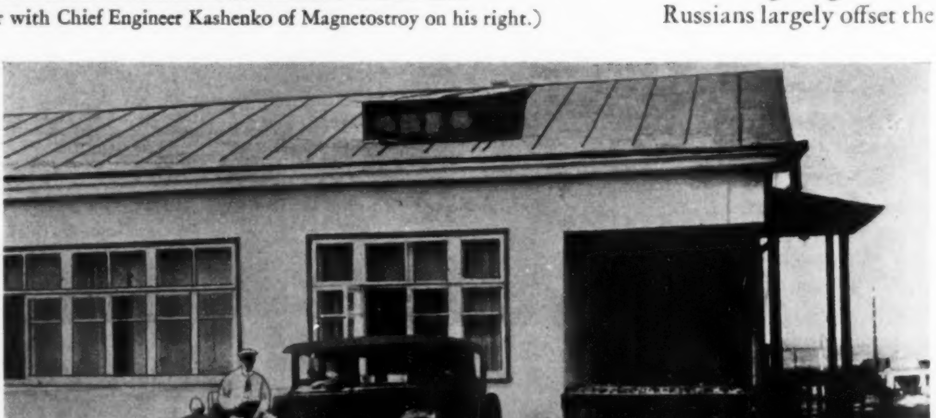
TURBO-BLOWERS FOR MAGNETOGORSK IN PROCESS OF ERECTION
(These blowers are of 115,000 cu ft per min capacity, the largest of their kind to date supplied by Gutehoffnungshütte and the General Electric Company.)

GENERAL PANORAMA OF THE SITE OF MAGNETOGORSK. TWENTY-FIVE SQUARE

RUSSIAN AND AMERICAN ENGINEERS INSPECTING A DAM SITE
(Author of paper in center with Chief Engineer Kashenko of Magnetostroy on his right.)

To these circumstances, nevertheless, the American engineer must be reconciled and must adapt himself before he can be worth his salt in Russian construction, because such features are inherent in the present Soviet scheme of things and cannot be overcome in a few months or even years. They no doubt constitute the greatest handicap to the rapid and successful industrialization of Russia. A generation, perhaps, may be required to introduce system and good management.

At Magnetogorsk the Russians largely offset the



QUARTERS OF AUTHOR IN MAGNETOGORSK, TYPICAL OF HOUSING PROVIDED FOR FOREIGN SPECIALISTS

Russian engineers, who are largely drawn from the intellectual classes, often exhibit a certain amount of resentment toward foreigners. It sometimes takes months of diplomatic effort to overcome this feeling and obtain the cooperation that is particularly essential when administration is by commissions and mixed authority, and this diplomatic engineering—or engineering diplomacy—must be continuous because frequent change of personnel is another characteristically Russian procedure.

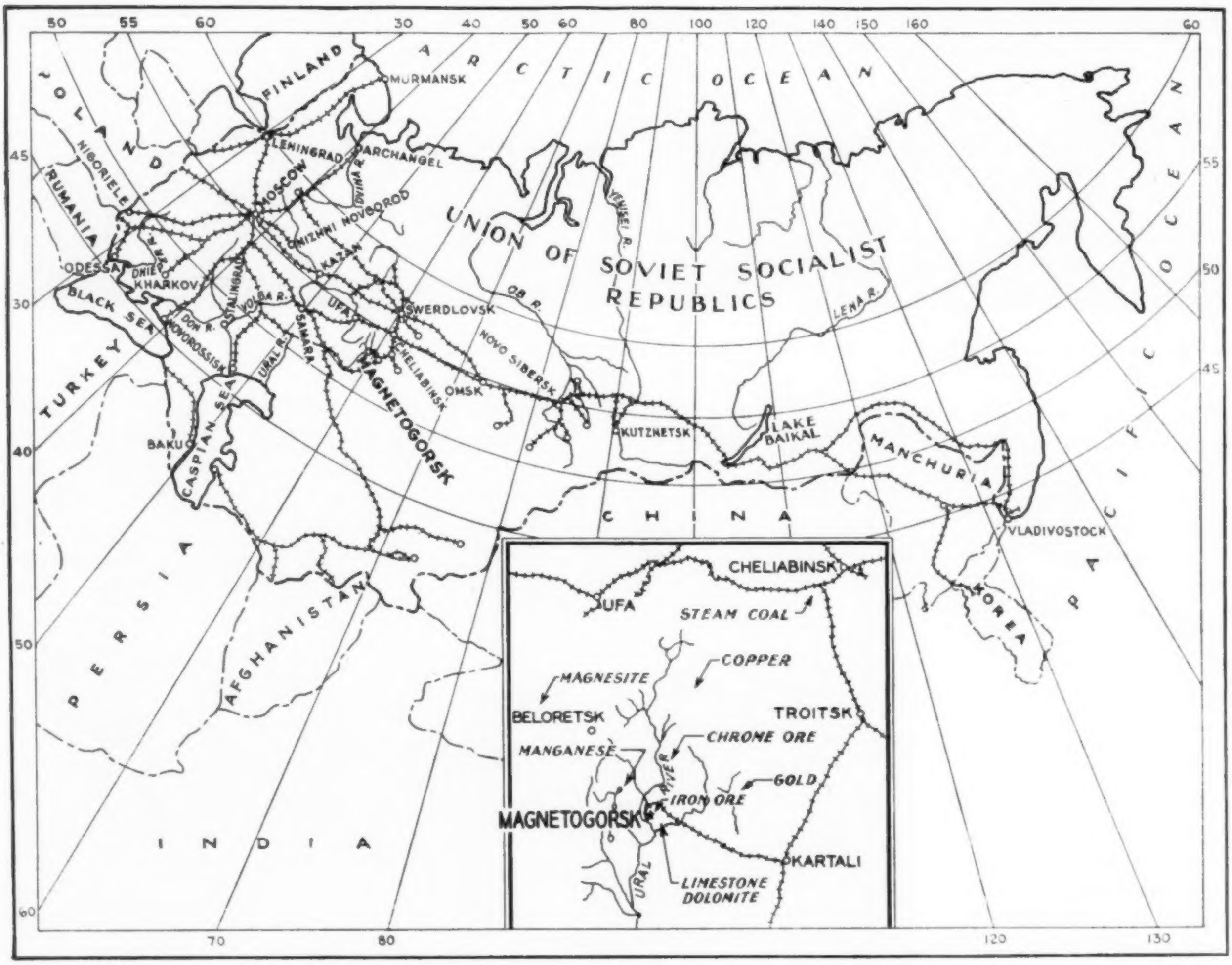
MILES OF CONSTRUCTION SERVED BY 100 MILES OF RAILROAD TRACK

defects of their system by great courage, infinite patience, dogged persistence, and the use of an enormous army of workers. Tempo is the god of the construction forces, and notwithstanding disregard for most of the principles essential to speed with economy, the work is frequently carried on at an amazing pace by sheer force of enthusiasm and mass action.

Not the least service of the Americans was their everlasting battle to prevent hasty workmanship from causing permanently defective construction. It was a fundamental policy of the McKee organization to insist upon a standard of quality in structures and assembled equipment that would at least insure a safe and operable plant, and at times this could only be accomplished by appealing to industrial leaders of the highest national authority. Other American supervising firms experienced the same trouble in this respect, and finally, during the summer of 1931, criticism and complaints directed at Moscow were successful in convincing government officials that there was something more

CAMEL CARAVAN—MAGNETOGORSK WITH PLANT IN BACKGROUND

GENERAL VIEW OF MAGNETOGORSK PLANT FROM SLOPE OF MT. ATACH



MAP OF THE UNION OF SOVIET SOCIALIST REPUBLICS, SHOWING LOCATION OF MAGNETOGORSK

APPROXIMATE DISTANCES IN MILES—FROM MAGNETOGORSK: KARTALI, 65; CHELIABINSK, 240; SWERDLOVSK, 390; KARAGANDA, 750; MOSCOW, 1500; KUTZNETSK, 1500; NIGORIELE, 2000; NOVOROSSISK, 2050; MURMANSK, 2750; VLADIVOSTOCK, 4400. MOSCOW TO LENINGRAD, 400; NIGORIELE TO VLADIVOSTOCK, 5850

(Insert shows mineral deposits in immediate neighborhood. All major requisites for the production of steel, except coking coal, are close by.)

to successful construction work than the excavation of material, the pouring of concrete, the erection of steel, or the laying of brick in record-breaking quantities. When Stalin himself, in one of his addresses dealing with the industrialization program, stressed the importance of quality, a great change in the attitude of the Russian engineers was immediately noticed, and the task of their American associates was tremendously lightened. The evidence of discipline within the party and obedience to governmental policy is just as pronounced as the lack of these qualities in the industrial organizations.

The divisions of the project handled by the American firm have been pushed forward rapidly to completion. Shipment of ore from the mines was begun in May, 1931, and the first units of the crushing and concentrating plant were started in the fall of the same year; the first two batteries of coke ovens were essentially completed in 1931, and also blast furnaces Nos. 1 and 2. The first coke was produced about December 25, 1931, and on January 31, 1932, furnace No. 1 was lighted.

TRIUMPHING OVER THE SIBERIAN WINTER

The functioning of the units that have thus far been put into operation can be considered satisfactory when the handicaps of Siberian winter weather and the limited experience of the Russian furnacemen are kept in mind. Magnetostroy elected to put its plant in operation without the help of an American operating crew, and thereby set a notable precedent in the U.S.S.R. for the starting of such a large and modern industrial establishment. After all, however, the Soviets are not without training in the making of pig iron. In 1930 their reported production was somewhat greater than that of Great Britain for the same period.

Of particular interest and satisfaction to the designing firm was the smooth working of the furnace stack, since the production of large tonnages of good metal from raw materials about which very little information was available made the proper determination of dimensions and selection of equipment an unusually

(Continued on page 497)

Current Problems of INDUSTRIAL MANAGEMENT

By JAMES D. MOONEY[1]

Probably the greatest weakness of industrial organization during the past decade has been the faulty control of the relationships between production and distribution. Our greatest difficulties during these days of depression arise out of our lack of capacity to take the helm boldly and steer a course that will take the industrial ship again into the fair-weather seas of busy plants, profits, and full dinner pails. . . . The depression has now lasted for about three years, and many of us are still waiting for some kind of inflationary miracle to put us back on "Easy Street." Certainly our Canadian and American pioneer ancestors would have had their coats off long ago to pitch into the job of driving their costs down and their production up. They were economic realists and knew that purchasing capacity can only be reestablished by getting production under way, and that production can only be increased by offering goods to the market at prices and values that will tempt an increasing number of buyers. . . . Distribution is our immediate, urgent problem, and must absorb all our waking hours. Distribution in its present chaotic state needs the attention of the engineer mind, needs the scientific approach with its respect for accurate identifications and standardized nomenclature, and needs a new respect for the value of truth and economic realities. . . . We must make some decisions and move on. Nothing can be so dangerous at times as standing still. Providence seems to take a kindly interest in men who go ahead, and fortune smiles on the daring.

THERE is nothing more depressing to a man who has spent his life in industry than walking through an idle manufacturing plant. Melancholy stillnesses have taken the place of the hum of machines, the whir of belts, the tuneful and rhythmic beat of forges and hammers, and the whistling and light chatter of workmen.

The imagination easily fills in the cheerless background of managers worried about the heavy burden of continual financial losses, and of workers' families becoming increasingly desperate in their fight against the daily miseries of hunger and cold.

What an amazing array of such idle plants we now view in the Canadian and American industrial scene! What a desperate situation the managers of industry find themselves in today!

Well, what of it? What are we going to do about it? What are we going to do about these idle manufacturing plants, about filling them again with production?

Today all the elements of industrial management converge into this main critical problem. Accordingly, in my observations on the current problems of industrial management, I shall try to emphasize such elements as may have some bearing on the possible solution of the all-important problem of reestablishing production.

Ironically, building up momentum again in our industries seems to depend not so much on things we can do right within the plant walls, as on things to be done outside, and on decisions to be made in the head office. Accordingly, I warn you that I shall spend very little time today actually in the plant, and very little time discussing the excellent instruments and technique available for efficient management within the factory.

The development in management methods during the past twenty years has been characterized by the perfection of details relating to production methods, by the increasingly extensive and intensive use of tools, and by the concentration of attention on the relation between direct labor costs and output. We have become experts at controlling and reducing the direct costs of production. We know how to produce quality goods in quantity at decreasing direct costs. So much for our progress. How have we failed? It strikes me that we can hope for a satisfactory answer to this question if we explore the situation as we find it in industrial management today.

MANAGEMENT AND ADMINISTRATION

Most of the great weaknesses in American management arise out of a condition of mind that seems to have grown alongside the development of our tools. We have become direct men, men of action; we have very little time either during the day's work or during the evening to philosophize about our general scheme of things, very little time to discuss the changes of the industrial tides to which from time to time we must adjust our own industrial companies. We spend too little time plotting our general direction and course. Perhaps the cutting edges of our own tools have fascinated us, and hypnotized us, and made us insensible to many of the

Address delivered at the Management Session of the Semi-Annual Meeting of The American Society of Mechanical Engineers, Bigwin Inn, Lake of Bays, Ontario, Canada, June 27–July 1, 1932.

[1] Vice-President of General Motors Corporation in charge of Overseas Operations; President of General Motors Export Company, New York, N. Y. Mem. A.S.M.E.

broad problems we must solve to protect the stability and growth of our industries.

In short, it has been made plain to us by the depression that we are good production managers, but that we have not succeeded too well as administrators of industry.

I should like to suggest this differentiation in the use of the words "Administration" and "Management:" Administration is concerned with the sphere of policy, with the general problem of fitting the particular industrial effort to its economic, political, and social environment, with the total overall investment approach, with the yearly budget, with the balancing of the general equities among the clients, the stockholders, and the employees. Management is concerned with the sphere of action, with the day-to-day decisions related to carrying out the policies, with securing the best results for the industrial effort under such conditions as impose themselves upon it from month to month, with making a monthly profit, or, under extremely adverse conditions, stopping the loss at a minimum, and finally with just decisions of the day's problems relating to the equities of clients, stockholders, and employees. In short, administration is concerned with the strategy of the industrial operation; management, with the tactics. Administration comprises the problems that lie on the desk of the president of the company; management includes the problems that lie on the desk of the general manager.

The present condition of the art of cost accounting serves as a rather useful example of the state of mind that has been prevalent in industry. Our cost accountants have developed a marvelous technique for providing us with accurate costs, to the fourth decimal place, of our direct labor and our production materials. But when the cost accountants and the managers or administrators come together to decide on the amount of overhead that shall be charged to make up the final factory costs, the discussions usually proceed without any definite principles to govern them, and end with an unnecessary sacrifice of profits or loss of position in the market because of faulty selling prices. The overhead ratios have not been harnessed by cost technique, even to the first decimal place.

Another example may usefully illustrate the condition of our management or administration minds in industry. Let us look for a moment at our development of transportation. In the transportation of materials and work in process within our factory walls we have become amazingly expert. We make a science of keeping handling costs within the factory to a minimum. We have not only developed a remarkable technique for making the material move by the shortest and quickest route from receiving to shipping door, but have provided the instruments, the conveyors, the factory trucks, the cranes and hoists, to handle the work in process with the minimum labor costs.

But what of the transportation costs outside the factory? What of the incoming transportation costs of our raw materials? What of the shipping costs of our products to the market? One of our rather common errors is putting the factory in the wrong place. The correct location of a factory, with due regard to the proper balancing of the factors, raw materials, market for the product, and labor, takes us into the area of general economics, demands of us some philosophy of administration. These areas we have been prone to despise, because we have prided ourselves on being practical men, and the consequence to industry has been the loss of millions in faulty general transportation arrangements.

INDUSTRY AND GOVERNMENT

The management mind in industry has always had a great contempt for politics. The point has been missed that although we in industry have continually dismissed politics and government as quite unworthy of the attention of serious-minded men like ourselves, politics and government have been continually increasing their interest in industry. This interest has arisen out of two causes: first, the expenses or costs of politics and government must be collected from industry; and, second, the growing magnitude of industry, with its ally finance, has challenged the power of politicians, and we see a recurrence of the age-old struggle for power with simply a modern complexion.

Industry has a huge stake in present-day political conditions and in present trends of political thought, and our administrators, if they are to protect our industrial operations from some of the dangers that are becoming increasingly threatening, must take a more aggressive position in many of these political situations.

I need hardly remind you that in the field of international politics, the various governments have made a muddle of reparations, war debts, and tariffs, and that accordingly a heavy hand has been laid on production and industry because of the disintegration of international distribution. In the field of national politics and government we have seen an amazing increase in the part government is presuming to take in regulating our industries and infiltrating our industrial operations, with the natural corollary of frightful taxes imposed on industry to pay the costs of such meddling.

There is a great deal of discussion going on at the moment about democracy, and men are wondering whether it is a failure. During the past year or two I have heard friends of mine raise the question in Canada, in England, in Australia, in New Zealand, and in America. Here's an amazing condition of political mind for us to confront: skepticism about democracy widespread among the descendants of men who struggled for centuries to perfect a scheme of things based upon constitutionalism and the defense of the rights of the individual against the leader-tyrants or the tyranny of the group. And the ghastly irony of the whole situation is that we have not been functioning at all under a democratic scheme since the World War—when our various governments preempted many functions affecting our economic and social lives and have since retained and even enhanced them—but have continually been drifting in our various countries into more or less highly centralized schemes of state socialism. A study of the

structural forms of governmental organization in history will convince you that such schemes of highly centralized government are very old-fashioned and very dangerous not only to the freedom of the individual but in a practical way to the healthy existence and growth of industry.

It may be very difficult for us in industry to resist these socialistic trends, but at least we can refrain from giving them our implied or active support. At least we must resist our temptations to dump our responsibilities on the Government, only to find later that the undertaking of these responsibilities by the Government has established its authority over our industrial operations in functional areas that lie outside the proper sphere of government conducted according to democratic ideals.

This struggle that is going on at the present time in the area of politics in the various countries throughout the world between democracy and state socialism is interesting to the administrator of industry, particularly because of the effects of either system of government on the economics and efficiency of production and distribution.

RUSSIA'S EXPERIMENT IN STATE SOCIALISM

The imagination of the world has been captured by the dramatic experiment in complete state socialism in Russia, and industrialists everywhere have been watching with excited interest the effects of the attempt at integrated industry, with all of the corollaries of highly centralized planning and control of production and distribution. The experiment seems to be coming off rather well, and Russia in the desperate emergency in which she found herself probably has been well justified in reverting to a scheme of government that in its main structural and psychological elements corresponds with the ancient forms of government that preceded the growth of the Greek democracies.

Democracy, however, must commend itself to the industrial administrator, not only because a man's personal liberties are just as important to him as his standard of living, but because in the long run democracy, with its implications of the importance of developing the individual, holds forth the best promise of raising the standards of living.

Democracy recognizes the natural instinct to acquire and own property. It presumes to make opportunity free and equal to all, and to let the best man win. It attempts to let the individual judge for himself. Democracy believes that it is best for the group to allow a free play of economic forces, and rely on the individual to make his own adjustment to these forces. Democracy does not offer industry the presumption of master minds, super-men leaders, master planners, but does offer the steady integration of economic increments that arise out of individual efforts, individual business judgments, and individual initiative. Democracy offers industry a guaranty against stagnation.

I have attempted to illuminate these few facets of the inherent interest of industry in politics and government, again as a means of challenging management in industry to recognize more fully the broader horizon of its responsibilities, and to seek a better solution of fitting its industrial operations to the various patterns of the present-day political, social, and economic environment.

COMPENSATION AND ORGANIZATION

Industrial administrators or organizers have still to recognize one very important element that is always to be found in any organization that has achieved stability, and this element is the presumption of continual relationship between the individual and the organization. An organization, to be strong and sound, must have its structure cemented with loyalty, and this loyalty can only be evolved out of implied continual and mutual interests.

The classically strong organizations of state, church, and army have made good use of this element. In industry, union labor leaders have made excellent use of the presumption of continual relationship between the union man and the union, and accordingly they have often been able to challenge effectively the natural leadership of management. Union leaders at least presume to accept responsibility for the continual welfare of the man. The acceptance of responsibility of course generates authority, and authority endows leadership.

Management in industry, on the other hand, makes very little pretense of a continual relationship between the industrial organization and the employee. Management hires and fires its wage earners on an hourly basis, and its salaried employees on a weekly or monthly basis. And these short units of time reflect rather accurately the amount of presumption that exists in industrial organization generally as to continuity of relationship.

The average industrial organization is about as stable in its personnel as the group of passengers on one of those steamers that leave London for the Far East with ports of call at Gibraltar, Port Said, Suez, Port Sudan, Aden, Bombay, Colombo, and Sydney. At every port some of the passengers disembark and new passengers come aboard. "Here today and gone tomorrow"—for the individual certainly does not develop coherence within the group, and no group can be developed into an organization unless the development of coherence is made possible by at least a reasonably continual relationship.

As the character of any manufactured product increases in value and complexity, its quality in production becomes increasingly and remarkably dependent on the continuity of the workers in employment whose skill and craftsmanship are imposed on that product. We are prone to forget that things are made by men's hands, and prone to place too much dependence on written engineering and processing specifications. A fine product in conception deserves the dignity of the arts-and-crafts atmosphere in production. Obviously, artizans and craftsmen must be continually related to the manufacture of a fine product, for intimacy with the product has a remarkable way of reinforcing the inherent skill of their hands. Again in this case the compensation scheme must contain elements that go beyond the hourly-

or daily-wage conception and supply something of an implied continual relationship.

There is no doubt that industry has suffered badly and is finding it very difficult to extricate itself from the depression because of the fact that the whole subject of compensation in industry has been frozen into the narrow mold of wage rates. Daily-wage rates for labor have been emphasized to the point where the other factors in the economic problem, security and actual standards of living, have been badly neglected. Leaders in industry, both managers and labor leaders, seem to lose sight of the point that a man's family eats every day in the year, that the children's shoes wear out from month to month, and that the mortgage on the home is payable annually. If these leaders could talk more frequently with the housewife they would find that she is far less thrilled at the prospect of fancy short-time daily wages for her husband, than by the prospect of removing the continually haunting specter of unemployment, with its concomitants, hunger and misery and hardship for the family. Further, these leaders, again both managers and labor leaders, seem frequently to forget that if the prices of things are forced upward by fancy daily-wage rates the average family suffers badly because such things get beyond the reach of the family income. Consumption of these things is restricted, the diminishing production creates unemployment, and unemployment destroys purchasing power—a vicious circle is constructed.

Purchasing capacity unfortunately has been identified and dramatized as a function of daily-wage rates, rather than as a function of the worker's annual earnings and the cost of living. Purchasing power depends fundamentally upon production and the facilitation of the interchange of products.

Employer and worker meet principally on the common ground of compensation, on the just division of the profits of the industrial effort. Obviously, with all the attention in industry focused sharply on daily-wage rates, the various implications of the compensation fail to include the element of continuance in the relationship between the worker and his employer.

Industry in its endeavor to strengthen its capacity for leadership in its own organization problems, must free itself from the shackles imposed by the overemphasis of daily-wage rates, and develop a broader and sounder philosophy of compensation. Industry must be free to change wage rates up or down to suit varying business and economic conditions, in order that costs can be adjusted to new market conditions and production maintained at as uniform a level as possible.

Industry, on the other hand, must face its responsibility of providing greater economic security for its loyal members. Unemployment insurance, health and accident insurance, and old-age pensions may seem to threaten industry with undue burdens of cost, but if industry does not accept a greater responsibility in providing solutions for the problems related to these elements of economic security, then political and labor leaders will. The costs will be far greater. Industry always finally pays the bills. Further, from its own standpoint of enlightened self-interest, industry should, and indeed must, take more advantage of the point that if the organization can make the individual feel that his security will be protected by the group, then he will give of himself more whole-heartedly to the interests of the group. A reasonable study of the principles of organization in the various forms of human group movement convinces one that no organization structure can hope for endurance unless it is cemented together with the element of an implied continual relationship between the individual and the group.

INDUSTRY AND ECONOMICS

Administration must face its responsibilities of acquiring a better understanding and knowledge of economic laws and of adjusting its various industrial efforts to the inevitable operation of these laws. Economics has been considered by practical managers as something to be left to the college professors and occasional loose discussions at the luncheon table. Meantime huge investments in plant, equipment, and tools are jeopardized or ruined because adjustments of these utilities to the ebb and flow of various economic tides are attempted too late.

Here, again, we face the general problem in management of broadening the outlook of the manager, of getting him to face his broader responsibilities to stockholders, clients, and employees. We must attempt a development and growth of managers into administrators. In our democratic scheme of things in industry we have prided ourselves on keeping the way open for the man at the bottom to rise to the top. We have protected fairly well the principle of free and equal opportunity for all. Consequently we have a great proportion of our managers who are "practical men"—men who are thoroughly experienced engineers, production men, or business men. We seem to have missed the point, however, that the area in which the administrator's daily work lies demands quite a different technique and knowledge and understanding from the area in which he may have operated as chief engineer, production manager, or sales manager. He must qualify as a "practical man" in this new area that definitely includes the problems of administration.

Administrators, to be "practical" and to do their work thoroughly, will find an understanding of the law of supply and demand, with its various corollaries, much more useful in their own day's work than the knowledge of how to set up a job on a milling machine.

Incidentally, what a contribution engineering could make to a better codification and understanding of economic laws! The whole field of political economy is badly in need of the services of the engineer type of mind, with the objective and scientific approach to problems, its contempt for loose talk, and its hunger for facts.

Certainly many of the general problems of industry cannot be solved at all accurately unless they are held up against the background of economic laws. The industrial operation must be guided with a steady hand to take the maximum advantage of economic currents. Steady production, with all its advantages of quality,

decently treated labor, lower average costs, and better profits, cannot be intelligently insured unless there is brought to bear on the problem a fundamental understanding of the general economic relation between the production or service utility and the market it is attempting to serve.

PRODUCTION AND DISTRIBUTION

Probably the greatest weakness of industrial organization during the past decade has been the faulty control of the relationships between production and distribution. Our greatest difficulties during these days of depression arise out of our lack of capacity to take the helm boldly and steer a course that will take the industrial ship again into the fair-weather seas of busy plants, profits, and full dinner pails.

Here again, the manager has been too busy with the day's production details to bother with a broad look around, and meantime the medicine men of high-pressure selling have taken over his distribution problems. And our high-pressure selling of the past several years has been characterized not only by a great development in the technique of "ballyhoo," but also by a lack of interest in the development of a philosophy or knowledge of the economics of distribution.

If you wish to prove this for yourself, examine carefully the enormous mass of literature that is available on selling, salesmanship, sales-organization methods, and advertising, and find, if you can, many coherent discussions of the economics of marketing: the general relationships of prices and supply and demand; the general relationships of unit distribution costs; the relation between the movement of the price level of a product upward or downward, and the discount spreads economically available for wholesaling or retailing; the fundamental similarities and differences of operating one's own branches or operating through distributers and dealers; the economics of flowing goods to the market that includes the factors of transportation costs, interest charges, and obsolescence; or, generally, the identification of the functions and costs of distribution on an economic plane.

We have gone aggressively into the erection and equipment of plants without a very coherent idea of the fundamental relationships between these production facilities and the markets they might serve to economic advantage. I myself have seen huge investments in plants, which incidentally are now standing idle, where some factor like the transportation costs of incoming materials was the only one considered in the problem of plant location, and where no attention at all seemed to have been given to the other important factors, such as the center of gravity of the market for the finished products, the quantity and character of the labor available, and the living costs in the area surrounding the location.

We have made a great fetish of saving pennies in direct production costs, but have been content meanwhile to waste dollars lavishly in distribution costs. The mechanisms of mass production have the excellence and finesse of the up-to-the-minute 12-cylinder motor car, but the designs and functionings of distribution schemes remind one of a 1914-model farm tractor.

Perhaps we might borrow usefully the approach of the modern mining engineer, who insists on making extensive geological researches and provings, and on blocking out great masses of ore in his mining property before he recommends to capital the investment of huge sums in mills and smelters. The days of the "divining rod" in mining are long since past.

Better still, the administrators of manufacturing industries might borrow some lessons from the mechanical and electrical engineers who design and operate electric power and light utilities. Here, generally, an excellent job has been done in relating the size of the plant and investment to the area or size of the market available for the service, in making such rates and classifications of rates as will result in the best load factors, and generally in establishing relationships that will provide the best return on investment under the market or service conditions that impose themselves on the electrical utility.

In the manufacturing industries we are badly in need of the development of a philosophy that will shed light on the problems of properly relating plant capacity and capital investment to the probable market that can be served by the plant. We need an exploration of the implications that the economic extent of the market geographically is dependent upon the character and complexity of the product, the unit value of the product, and the amount of specialized tooling needed for its production.

DISCOVERY OF ART BY INDUSTRY

During the height of the boom years, we industrialists discovered art. We suddenly became conscious of the line and form and color of our products. This is something to be devoutly thankful for, because the idea of making our products more beautiful dramatizes not only the ideal of improving our quality standards but also the prospects of creating a real union between the methods of mass production and the spirit of the arts and crafts. There is one important distinction that we must make, however, in this area of line and form and color: we must make a distinction between style and fashion. We can well afford to go on making our products inherently better looking, but we must beware of following generally the fashion will-o'-the-wisp because we have too big a job to do during the impending forward period of getting our costs and prices down on manufactured goods. In short, the increase in the style value or attractiveness of the product must be maintained, but fashion must be kept in proper relation to the economic value of the product to the user.

As production men we have learned from experience that a manufacturing plant operates to the best all-around advantage to capital, to labor, and to clients, if it is kept reasonably oversold. But as administrators we seem to lose sight of this entirely in our general planning of production and in the investments we make in plant, equipment, and tools. Not only are there the violent fluctuations in our production that arise out of economic

cycles, but there are also continually rather sharp peaks and valleys that arise out of seasonal or other moderate disturbances in the market.

In our ambitions to capture extended markets or to deal staggering blows to our competitors we must face the law of diminishing returns, with the probabilities of costs rising much more rapidly than the proportion of the market that we succeed in dominating.

Administrators in industry must face their responsibility more fully to relate the capital investment in production facilities to the general economic background and the probable market available for the product so that greater assurance can be provided for continual operation, a continual fair return on the capital employed, and continual employment.

THE PRESENT CHALLENGE TO MANAGEMENT

Well, in this present desperate situation of industry, and to use the words of the Canadian and American soldiers during the war, "Where do we go from here?"

Our idle plants, with their corollaries of unemployment and the wasting away of capital, are hungry for production. The prices of prime products, such as wheat, cotton, wool, rubber, copper, oil, have been sinking lower and lower for three years, and it is becoming increasingly evident that we had better abandon the hopes we have clung to tenaciously during these years that the general price levels of these products would bounce back upward and save us all. Many countries and areas are now in active and aggressive production in these things, and as their surpluses offered in the world's trading centers establish the price levels of these products and react accordingly on the prices of the products in their own respective domestic markets, we might better accept the present general price levels as they are and get on from there. If we accept these levels and they do bounce back upward, certainly the outcome will be much happier than if we pursue our present course of nursing our dreams, doing little, and sinking deeper and deeper into the mire of disaster.

The depression has now lasted for about three years, and many of us are still waiting for some kind of inflationary miracle to put us back on "Easy Street." Certainly our Canadian and American pioneer ancestors would have had their coats off long ago to pitch in to the job of driving their costs down and their production up. They were economic realists and knew that purchasing capacity can only be reestablished by getting production under way, and that production can only be increased by offering goods to the market at prices and values that will tempt an increasing number of buyers.

Although advertising, intensive selling, modern sales-organization methods, and other helpful instruments like time payments have done much to aid distribution, we have been too prone to lose sight of the consumer's price, the price-value relationship, and the quality and attractiveness of the product as by far the most important factors in broadening and stabilizing the distribution of any product. These factors relating to the product are emphatically most important now because of the leaner purses of the buying public and the present extremely critical attitude of buyers.

In making up our costs as the basis of our selling prices, and particularly in arriving at what charges to include in the overhead costs, administration must begin to wake up to the point that if much of the floor space and equipment and many of the tools have been idle for a long time there is no use in continually trying to charge increments for all of these that result in prices which evidently the public refuses to pay. I have actually met managers during the last year who have increased their "non-variable" overhead charges per unit because, as they explained, there were fewer units being sold, and accordingly they had to increase the charge per unit to cover their costs and profits. That their markets were shriveling up did not seem to impress them particularly. This kind of costing philosophy kills the goose that lays the golden egg. Naturally, we must form our plans to make a fair return on our whole capital investment, but our only reasonable chance of doing this lies in hanging on to our market position, maintaining whatever production we can in the plant, and taking steps gradually to increase this production to normal. Idle plants lose money; full plants make money. A plant that stands idle very long begins to come under discussion for liquidation; why not try slow liquidation by leaving out much of the depreciation and obsolescence factors in the overhead costs, place a much lower selling price on the product in the market, take a sporting chance at filling the plant, and then drive the other costs down far enough so that more of the depreciation and obsolescence charges can again be picked up and credited to reserves or profits?

CONCLUSION

In conclusion, I should like to make a suggestion to you gentlemen who are interested in administration and management that you accept the challenge of developing a philosophy of fitting your respective operations more accurately into the present economic, social, and political environment—a philosophy that will enable you better to discharge your overall responsibilities to stockholders, employees, and clients. I should like to suggest further that you pitch in first and immediately to the general problem of hooking up again your production facilities with the market, however discouraging the outlook may be at the moment. Distribution is our immediate, urgent problem, and must absorb all our waking hours. Distribution in its present chaotic state needs the attention of the engineer mind, needs the scientific approach with its respect for accurate identifications and standardized nomenclature, and needs a new respect for the value of truth and economic realities.

Here, then, lies the challenge of the situation, the challenge to industrial management to get on with its job of making the wheels of industry spin again, of filling idle plants again with production. We must make some decisions and move on. Nothing can be so dangerous at times as standing still. Providence seems to take a kindly interest in men who go ahead, and fortune smiles on the daring.

The TAXABLE VALUE *of* MANUFACTURING PROPERTIES

By CHARLES T. MAIN[1]

At this time of economic and industrial distress, there seems to be no satisfactory method for determining a fair basis for taxation of industrial plants and other property closely associated therewith. The following suggestions are made in an endeavor to set up a logical method of getting a closer approximation of values for the purpose of taxation than has been used for the past few years or is now in use.

AT THE Annual Meeting of The American Society of Mechanical Engineers held in December, 1897, the author presented a paper entitled "The Valuation of Textile Manufacturing Property."[2] Most of the statements which were made in that paper were applicable to other branches of manufacture, and nearly everything that was stated then is now true, except that there is at present very little or no immediate market for textile mills and some other manufacturing properties, thus upsetting our former standards of values for various purposes.

It is proposed here to discuss taxable values and to attempt to set up a method by which an agreement can be arrived at between owners and assessors as to what would be a fair assessment.

At this time of economic and industrial distress, there seems to be no satisfactory method for determining a fair basis for taxation of industrial plants and other property closely associated therewith.

The following suggestions are made in an endeavor to set up a logical method of getting a closer approximation of values for the purpose of taxation than has been used for the past few years or is now in use.

The assessors have taken oath of office to make assessments based on fair market value.

Prior to 1914, replacement cost less depreciation was usually considered as fair market value for most properties.

Since 1914 there have been many rapid changes, up and down, in replacement costs, the extremes of which could not be interpreted as determining market values of any permanence.

In recent years regional competition and excessive expansion, particularly in the cotton textile industry, have caused liquidation of many properties and a diminution in value of those remaining.

With economic conditions as they are now, replacement costs less depreciation do not, in general, represent fair values for taxation purposes. Neither do prices brought in forced-liquidation sales afford a fair basis of value for similar properties if there is any possibility that these properties will be used again for profitable purposes in the near future.

What can be set up as a substitute which will be worthy of consideration and may be argued with some assurance of compromise between the owners and assessors as representing fair values for the purposes of taxation?

Starting with the year 1914 with an index of 100, there were great fluctuations of construction costs until the year 1925. During the years 1925 to 1930, inclusive, costs were fairly uniform, with an index of about 205 on the building-construction chart of *Engineering News-Record*. During the years 1930 and 1931, the economic conditions of that period, with a decline in the cost of labor and materials, caused the building index of *Engineering News-Record* to drop to about 160, and that of the author's organization for mill buildings to about 170.

About April 1, 1932, one of the largest and most reliable construction companies placed the general index at 130 when referred to 100 as of 1914.

Cities and towns must have some money for conducting public affairs. The industries must not be taxed so excessively as to drive them out of existence. For the purpose of trying to arrive at a fair compromise between the owners and the tax assessors, the author would suggest the following method of procedure.

BUILDINGS

1 Estimate as closely as possible the replacement cost of the buildings as of April 1, 1932, or for any other date of taxation, using either previous data corrected for construction cost as of the date required, or by direct estimate.

2 Having established a replacement cost for the exact structure or structures under consideration, there may be allowances to be made for obsolescence for the following reasons:

- *a* Because the building was so designed as to cost more than is necessary for the purpose to which it is put.
- *b* Because of changes in methods of operation or of machinery, the buildings may not be now economical for the present occupancy or operation.
- *c* Because of changes in the character of the business or its operation, there may be floor space

[1] Chas. T. Main, Inc., Engineers, Boston, Mass. Past-President A.S.M.E.

[2] Trans. A.S.M.E., vol. 19 (1898), p. 119.

Contributed by the Management Division and presented at the Semi-Annual Meeting of The American Society of Mechanical Engineers, Bigwin Inn, Lake of Bays, Ontario, Canada, June 27–July 1, 1932.

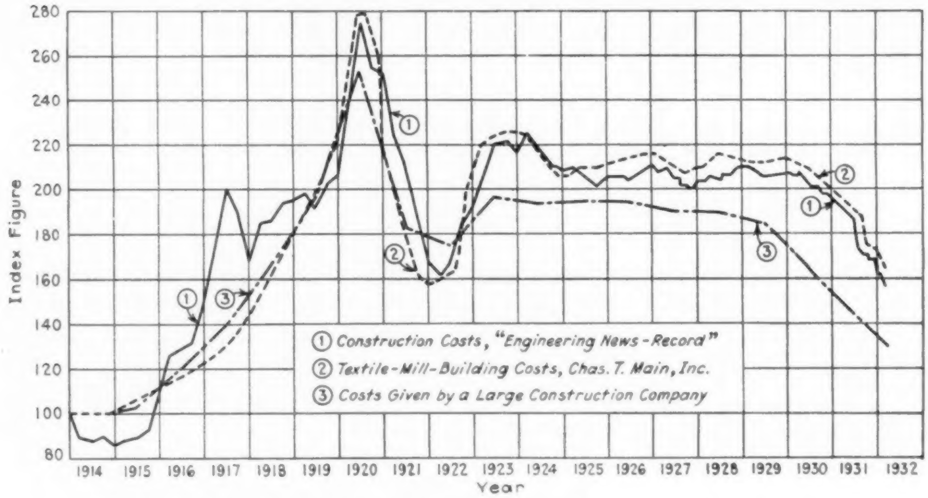


FIG. 1 GRAPH SHOWING COST TRENDS IN BUILDING CONSTRUCTION

which no longer is essential to the business and which is not useful for any other purpose.

3 After the foregoing allowances have been made, a figure is arrived at which represents the value of the buildings *if new*, provided they are being used for some useful and remunerative purpose.

There is then to be applied:

d Depreciation for age and wear and tear.

4 After this allowance has been made there remains a figure which would be an indication at least of the value of the buildings as they are, provided they are in use for some remunerative purpose.

Up to this point we have been dealing with items of value which are not subject to great differences in opinion. Beyond this point there is no consensus of opinion and no basis for the determination of taxable values, and because of the forced-liquidation sale of similar properties it is argued by some that there is very little value left on which to base taxes.

This same reasoning might be used in connection with a house or store which is for rent but temporarily vacant; that because there is no revenue, it has no taxable value.

5 If the buildings are not in use, or are in use for a purpose which is not remunerative, and are kept in use with the hope that at some time in the reasonably near future the business will again become profitable, there may be a value which might be called "potential value," which might be used as a basis for taxation, "fair market values" having disappeared.

This potential value is speculative, its measure depending upon the time which will elapse before the property will again be used profitably.

Any one contemplating the purchase of such property would be obliged to estimate the length of time that the property will remain unprofitable, and what he would deduct from the estimate of value arrived at under (4) for the carrying charges for the assumed period that it must be carried.

The carrying charges would be interest, depreciation, insurance, taxes, repairs or upkeep, heating, caretaking, and administration. All of these constitute a serious burden on the property. While they cannot all be measured in percentages, it is probable that they will amount in a year to about 10 per cent of the replacement cost of most mill buildings. For one year's delay in usefulness this would mean a reduction of approximately 10 per cent of replacement cost. Some of these items could be taken directly from the books of the company.

If it seemed possible or probable that the length of time that the property would be unprofitable would be so great that the carrying charges would eat up all the estimated value as determined by (4), then there would be no value left and the property should either be disposed of at the earliest possible date by sale, or, if there is no market, the buildings should be torn down and the land revert to the community for playground or park purposes, or for any useful purpose to which it could be put.

MACHINERY

For the purposes of illustrating the procedure in connection with machinery, let us consider the method as applied to cotton textile machinery. The same principle will hold in connection with machinery of any other industry.

During the period since 1914 there have been great fluctuations in the prices of textile machinery, but for the past six or seven years "asking" prices have been fairly constant at about 180, assuming the index for 1914 as 100. There has not been any change in asking prices recently.

The following method of procedure is suggested:

1 Estimate as closely as possible the replacement cost as of April 1, 1932, or for any date of assessment.

2 Allow for depreciation due to obsolescence.

For the purpose of illustrating the effect of obsolescence, let us consider what changes and improvements have been made in cotton textile machinery in recent years.

The opening and mixing department has undergone a forced reorganization to a large extent, and the picking process has experienced almost revolutionary machinery changes.

While no fundamental changes have been made in the card room, card-room machinery has been improved in many details so that machines built twenty years ago are now practically obsolete.

Long-draft spinning is an outstanding development. There is a tendency to apply similar equipment to roving.

There is further a marked tendency to the use of larger packages.

Old-style standard spoolers and warpers are obsolete today.

Slashers have been improved by new temperature and pressure controls, and in special cases by the combination of hot-air and cylinder methods into one machine.

Twisting and winding have been improved by the use of higher speeds and larger packages, and new types of winding machinery have been developed.

Since the development of the automatic loom there have been no changes so radical as that from the non-automatic to the automatic loom. There have been, however, many other improvements of importance which affect seriously the item of obsolescence in the weaving department.

3 After the application of the factor of obsolescence, there is to be a further reduction for depreciation due to age, wear and tear, etc.

4 The result obtained represents the value of the machinery as it is, provided it is being employed for some useful and remunerative purpose.

5 If the machinery is in use but it cannot produce a profit, or not in use but standing in expectation of a more prosperous time in the reasonably near future, there may be a value which might be called "potential value," which might be used as a compromise basis of taxation.

As in the case of buildings, this potential value is speculative, its measure depending upon the time assumed which will elapse before it is again in use on a paying basis.

A prospective purchaser must determine what, in his opinion, this period will be, and what he must deduct from the value previously determined for the carrying charges for the assumed period that it must be carried.

The carrying charges will be interest, depreciation, insurance, taxes, upkeep, caretaking, and some increase in the risk of further obsolescence. Some of these items are not measured in percentages, but the total can be determined approximately and will amount to about 12 per cent a year on the replacement cost.

The foregoing is illustrative of the carrying charges which are necessary for machinery in any other industry. Each industry should be treated in accordance with its individual characteristics.

LAND, TENEMENTS, AND POWER

Conditions vary so greatly in different plants and in different localities that it will be necessary to give individual consideration to these and, perhaps, some other items.

Jeannette Griffith

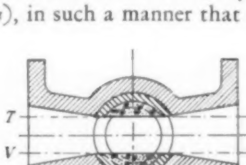
FRICTIONAL RESISTANCE OF COCKS[1]

Reductions Effected by Changes in Internal Contour

DURING an investigation of the frictional resistance of a certain widely used type of cock, it was indicated that considerable improvement might be effected by modifying the internal contour so as to reduce eddy loss.

Six 4-in. cocks were accordingly obtained, of the design shown in Fig. 1; also, for purposes of comparison, a standard 4-in. gate valve. As received, these cocks had plugs cored out so that the central free cross-sectional area at right angles to the flow was as great as, or greater than, that of the circular inlet or outlet, as indicated at *A*, *B*, *C*, *D*, Fig. 1.

Two of the cocks, designated hereafter as "Regular," were tested as received. A third cock, later referred to as "Top and Bottom," had a filling of "Smooth-On" cement plastered both within the cock body and the plug, as shown in Fig. 2(*a*), in such a manner that all space above the tangent plane *H-J* and below the tangent plane *K-L* (or, in Fig. 1, above plane *M-N* and below plane *P-Q*) was filled completely. The fourth and fifth cocks, labeled "Sides" [Fig. 2(*c*)], had "Smooth-On" plastered within the core only, so as to fill all space to the left of plane *X-Y* and to the right of plane *E-Z*. (See plan view, Fig. 1. The cored spaces behind planes *T-U* and *V-W* were filled in.) The sixth cock, referred to as "Top, Bottom, and Sides," had its interior filled with "Smooth-On" in such a way that a composite of the contours of Figs. 2(*a*) and 2(*c*) resulted, as shown in Fig. 2(*b*). The "Smooth-On" was carefully troweled into place, and after it had hardened was freed from roughnesses with a file.



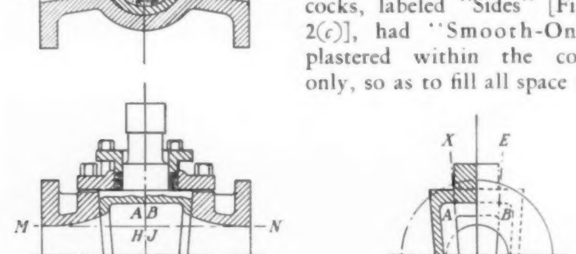


FIG. 1

Fig. 3 shows four of the cocks vertically placed in series with an orifice in a 4-in. standard pipe line carrying seawater. Across each cock was an inverted differential manometer connected to taps respectively 10 in. upstream and 32 in. downstream from the flanges. These distances, as shown in one of the tests, placed the taps beyond the region of turbulence due to the cocks. Table 1 gives the readings taken during the first test.

The superiority of the "Sides" type of cock is strikingly shown, as it is seen to have had only about one-half the frictional resistance of the "Regular" cock. Expressed differently, for a given pressure loss the "Sides" cock would have discharged about 35 per cent more water than the "Regular" cock in a given time. Also shown is the unfavorable result of filling in only the "top and bottom" of the cock. This produced a cock inferior in every case to the "Regular" one.

TABLE 1

Reading No.	Orifice[1] readings Diff., in. Hg.	Flow, gpm	—Overall pressure drops across cocks (in inches of water)— "Regular"	"Top and bottom"	"Top, bottom, and sides"	"Sides"
1	8.06	...	2.5	2.8	2.0	1.3
2	8.06	...	2.3	2.4	2.5	1.3
3	8.06	...	2.1	2.2	2.4	1.4
Avg.	8.06	137	2.3	2.5	2.3	1.3

[1] Orifice 1.85 in. in diameter in 1/8-in. plate, with full-flow taps.

From Table 1,

$$\left(\begin{array}{c}\text{Coefficient of discharge}\\ \text{of ``Sides'' cock}\end{array}\right) = \left(\frac{2.3}{1.3}\right)^{1/2} \times \left(\begin{array}{c}\text{Coefficient of discharge}\\ \text{of ``Regular'' cock}\end{array}\right)$$

Or, for a given overall pressure drop,

$$\left(\begin{array}{c}\text{Rate of discharge}\\ \text{through ``Sides'' cock}\end{array}\right) = 1.35 \times \left(\begin{array}{c}\text{Rate of discharge}\\ \text{through ``Regular'' cock}\end{array}\right)$$

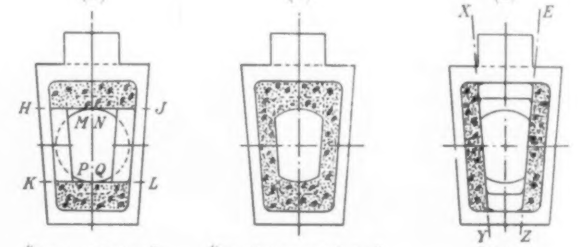


FIG. 2

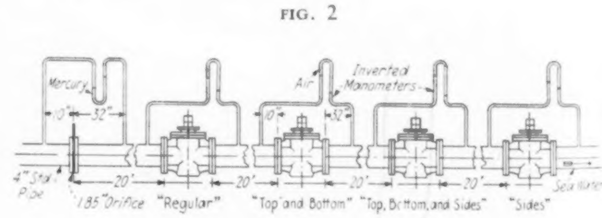


FIG. 3

As the result of this and other tests in which the sequence of cocks in Fig. 3 was changed and in which the cocks were bolted up with their plugs vertical as well as horizontal, it was found that a reduction of between 25 and 50 per cent in overall friction loss could be effected by merely filling in the sides of the cored space within the plug so as to continue the lines of the port openings smoothly through the cock, from end to end. When modified as described, the cocks had a resistance from 0 to 50 per cent greater than a typical standard-weight gate valve.

[1] Contributed by Frederick W. Isles (Mem. A.S.M.E.), Plant Engineer, Hydrogenation Plant, Bayway Refinery, Standard Oil Co. of New Jersey, Bayway, N. J.

Progress in the Use of HYDRAULIC EQUIPMENT *on Production Machinery*

By J. P. FERRIS[1] and E. WIEDMANN[2]

DURING the past few years the use of hydraulic motions on machine tools and other machinery has progressed steadily, and has adapted itself with remarkable flexibility to the requirements of various types of equipment. The advances have been primarily in matters of design rather than in the form of new principles.

While five years ago the machine-tool industry was the principal consumer of hydraulic equipment, many other fields have been entered since that time. One of the most promising is that of driving paper machines and conveyors. Accompanying the rapid spread in the use of hydraulic equipment on machinery, there has been an equally rapid increase in the understanding of the principles embodied, and a corresponding increase in the skill with which engineers in various industries have adapted hydraulic equipment to their needs.

The principles underlying this type of equipment have been discussed several times in the technical press, and the mystery surrounding this art has been gradually displaced by a rather general knowledge of facts based on a large amount of experimental and laboratory work. As a result of this situation, seemingly difficult hydraulic applications are now being analyzed and engineered just as accurately as are the applications of older and more familiar mechanical and electrical devices. This paper records the progress of volumetric hydraulic units on machine applications.

The simple throttled systems that have been used on light grinders, drilling machines, etc. during the last five years have also undergone considerable development, and their performance has been greatly improved. Neither the space nor the data are available to the authors to present an adequate discussion of this phase of the subject.

SEQUENCE CYCLES

Hydraulic drives have always had certain obvious advantages, some of those which are best known being extreme flexibility of speed ratio, cushioned application of forces, and ability to take extreme peak loads smoothly and without damage to the mechanism. Another interesting advantage of the use of hydraulic equipment with which the mechanical public is not so familiar is its adaptability for obtaining sequence cycles involving two or more motions. A number of cylinders or motors can be arranged to go through a series of motions, all motors taking their oil from the same pump. The valving is so arranged that a complete interlock results; no cylinder or motor can move except at the proper time in the cycle, because the oil flow to that motor is obstructed until the motor preceding it in the cycle has completed its motion. There is no general means of accomplishing this, as each job is different and requires its own solution. Another advantage of the hydraulic drive is the possibility of stopping the tool slide against a positive stop for extreme accuracy of length of travel.

PUMPS FOR FEEDING

Variable-displacement pumps designed for machine-tool-feed use usually include one or two predetermined rates of displacement that can be set or changed during the cut. On the smaller jobs only one pump is used, and rapid traverse is obtained by increasing the pump stroke automatically to its maximum to the rapid-traverse portion of the cycle. In cases where this system does not give a sufficient volume of fluid for rapid traverse, a design is used which includes one variable-displacement plunger pump and a large gear pump for rapid traverse, with suitable valving to bypass the gear pump when it is not being used and to connect either of the pumps with the external circuit. Fig. 1 shows a diagram of such a pump, in which all of these elements are designed into a compact unit, and Fig. 3 its external appearance. This diagram shows the variable-displacement piston-type pump *A*, the constant-displacement gear-type rapid-traverse pump *B*, the selector valve *C*, the reversing valve *D*, the pilot valve *E*, and the two feed adjustments *F* and *G*. The design includes pick-off gears which make it possible to obtain any desired ratio between the volumes pumped by the feed pump and rapid-traverse pump. The motions of the valves *D* and *C*, as well as of the hydraulic cylinder *K*, are entirely controlled by the pilot valve *E*. This latter valve has seven positions: rapid traverse forward, fast feed forward, slow feed forward, neutral, slow feed reverse, fast feed reverse, and rapid traverse reverse, and any of these functions may be obtained by simply locating it in the appropriate position. The fast- and slow-feed adjustments are preset by means of the screws *G* and *F*, respectively, and

[1] Chief Engineer, The Oilgear Company, Milwaukee, Wis. Assoc-Mem. A.S.M.E.
[2] Assistant Chief Engineer, The Oilgear Company, Milwaukee, Wis.

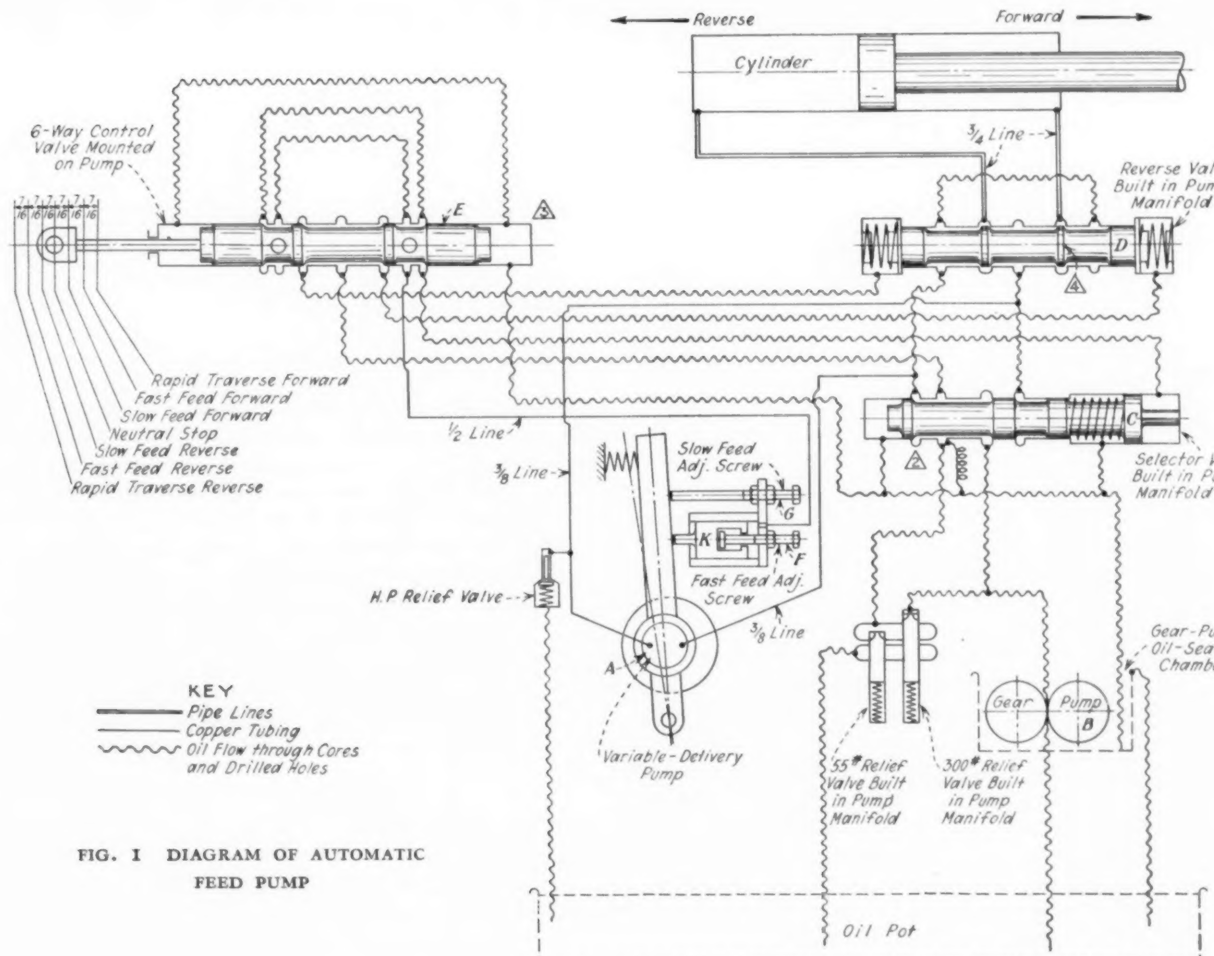


FIG. 1 DIAGRAM OF AUTOMATIC FEED PUMP

the corresponding delivery rates are selected by locating the pilot valve in the appropriate position.

Experience has confirmed the advisability of supercharging the variable-displacement pump used for feeding, and this is done in all volumetric feeding units. It necessitates providing a source of oil at low pressure from an auxiliary gear pump, and this oil is also frequently used for operating external control devices.

Efforts have been made to standardize the pumping and control equipment so that as few pumps as possible will take care of a large number of standard and special applications. This process of standardization has been difficult to effect because of the extreme variety of functions and speed ranges demanded.

All of the pumps in this line can be equipped with a compensating device that will hold the delivery substantially constant irrespective of changes in the temperature of the oil. With the volumetric system, changes in temperature affect only the leakage of a variable-displacement pump. Thus it is only necessary to compensate for a small discrepancy.

All of the pumps in which rapid traverse is provided in addition to feed in the same body can also be equipped with pressure compensators that will increase the stroke of the feeding pump slightly as the pressure rises, so that the net delivery can be made independent of the pressure encountered. It is even possible to overcompensate so that the resultant delivery is slightly greater for any given setting when the pressure rises.

HYDRAULIC MOTORS

Great progress has been made in the performance of rotary hydraulic motors, particularly at slow speeds. Motors are now available in which the torque delivered exceeds 98 per cent of the theoretical value. Starting torques range from 85 to 90 per cent of the theoretical. (Peak starting torques are obtained by raising the pressure momentarily.) The former figure is significant in demonstrating the high running efficiency, and therefore long life, of the units under running conditions.

The high torque efficiencies at starting enlarge the field for the use of variable-displacement hydraulic motors where it is desired to transmit a constant power over a considerable range of motor speeds. Whereas five years ago these motors could not be used at a stroke adjustment below about 40 per cent of maximum, it is now feasible to use them down to from 10 to 20 per cent of maximum, although there are still limitations in-

volved as far as maximum rotative speeds are concerned.

A typical application where this high torque efficiency of the motor is a necessity is on constant-power drives for reels in which the effective diameter of the reel increases as the material winds up. In order to maintain a constant tension on the material and a constant linear speed, it is necessary that the torque of the hydraulic motor increase as its speed decreases. This is accomplished by using a variable-displacement hydraulic motor with automatic control which increases the displacement of the motor as the diameter of the roll increases. This is accomplished without feelers, solely in response to the pressures existing in the hydraulic system. It is sometimes necessary that the motors operate down to one-fourth stroke, and it is obvious that high torque efficiency is needed in order to obtain good control over the tension in the material.

FEEDING PUMPS

One of the most popular pump and control units is shown in Fig. 2. The feed pump is of the high-pressure variable-displacement type and has a capacity of 550 cu in. per min. A small low-pressure constant-delivery pump used for supercharging is embodied in the same unit, and is of the flange-type design; it is furnished with an individual oilpot or can be built conveniently into the base of the machine. The flange also contains the necessary relief valves, stroke-adjustment lever, and a piston-type control valve whereby feed or rapid traverse can be selected in either direction. All the above-mentioned parts are accessible from the front and can be easily adjusted. This pump is used on a large variety of hydraulic machines where a ratio of rapid traverse to minimum feed of 25:1 with a small-rod cylinder, or 50:1 if a 2:1 differential cylinder is used, is sufficient.

To satisfy increasing demands for more rapid traverse

Fig. 2

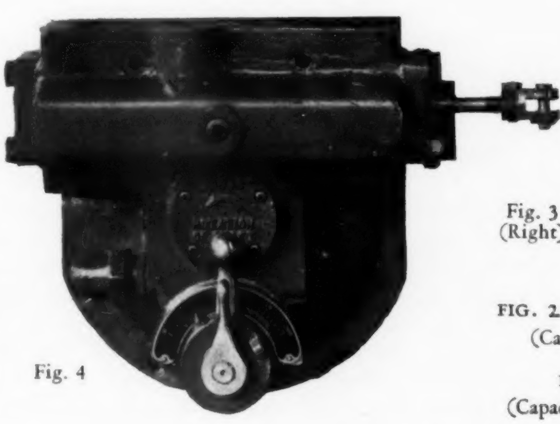


Fig. 4

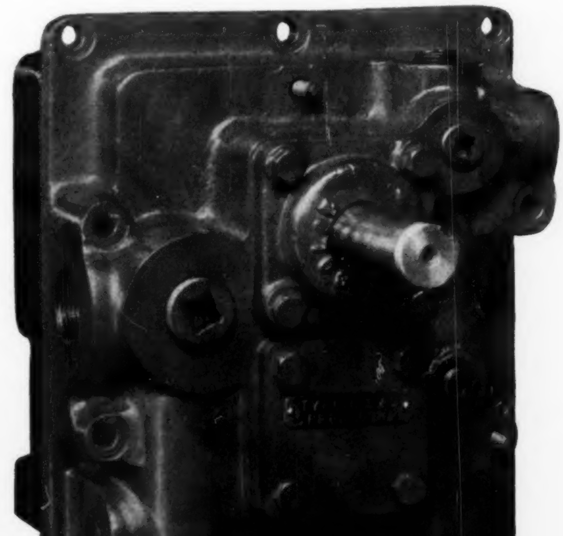


Fig. 5

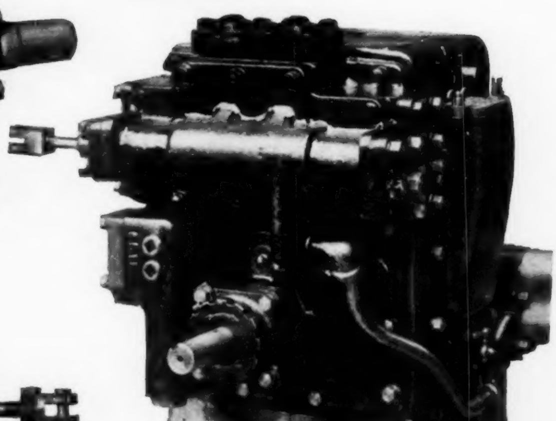


Fig. 3 (Right)

FIG. 2 HIGH-PRESSURE VARIABLE-DELIVERY PUMP
(Capacity, 550 cu in. per min; overall height, 19 in.)

FIG. 3 VARIABLE-DELIVERY PUMP
(Capacity, 3600 cu in. per min; overall height, 22 in.)

FIG. 4 SMALL VARIABLE-DELIVERY PUMP OF FLANGE-TYPE DESIGN

FIG. 5 DOUBLE CONSTANT-DELIVERY PUMP

on installations where considerable time was lost due to an unusually long rapid approach and return stroke, additional units, with separate constant-displacement pumps for rapid traverse, were developed. One of these units is of the same general design as that shown in Fig. 3, except for a separate control valve and an enlarged constant-displacement pump. The latter provides a ratio of 100:1 between rapid traverse and minimum feed, and is also used for supercharging.

The unit shown in Fig. 3 has a rapid-traverse capacity of 3600 cu in. per min, and a seven-position control valve is used to select two predetermined feeds or rapid traverse in either direction. A diagram of this type of pump was shown in Fig. 1.

To complete the line of standard feed pumps, another small unit, shown in Fig. 4, was added. This unit is a flange-type design for convenient mounting, and contains a variable-delivery high-pressure pump of the usual capacity with stroke adjustment, a relief valve, and a four-position control valve. The valve is capable of handling a large rapid-traverse volume supplied by a separate constant-delivery pump similar to the one shown in Fig. 5. The fact that different sizes of the rapid-traverse pumps can be selected makes this latest development a very flexible and useful device. The pumps of Figs. 4 and 5 are often combined into one unit with a common drive, but they are just as frequently mounted on the machine base with an integral oilpot.

VARIETIES OF MACHINES SUCCESSFULLY EQUIPPED WITH HYDRAULIC DRIVES

Many varieties of machines have been successfully equipped with hydraulic drives.

Vertical multiple-spindle drilling machines are equipped with a high-pressure variable-delivery pump. This pump is utilized at its maximum capacity for rapid traverse, and a differential system is employed to further increase the rapid-traverse rate. The movements of the four-position valve are controlled by a trip mechanism of the load-and-fire type. (This trip mechanism is connected with a treadle which is located within easy reach of the operator and permits him to have both hands free.) In case of emergency at any point during the cycle, the head can be reversed by depressing the treadle a second time.

Fig. 6 shows a fully interlocked automatic drilling machine with a hydraulically operated indexing table. This particular design is so arranged that the table must be completely indexed and an index pin driven home before it is possible for the head to start down. Any possibility of the drills striking the work or fixtures at an incorrect position is thus avoided.

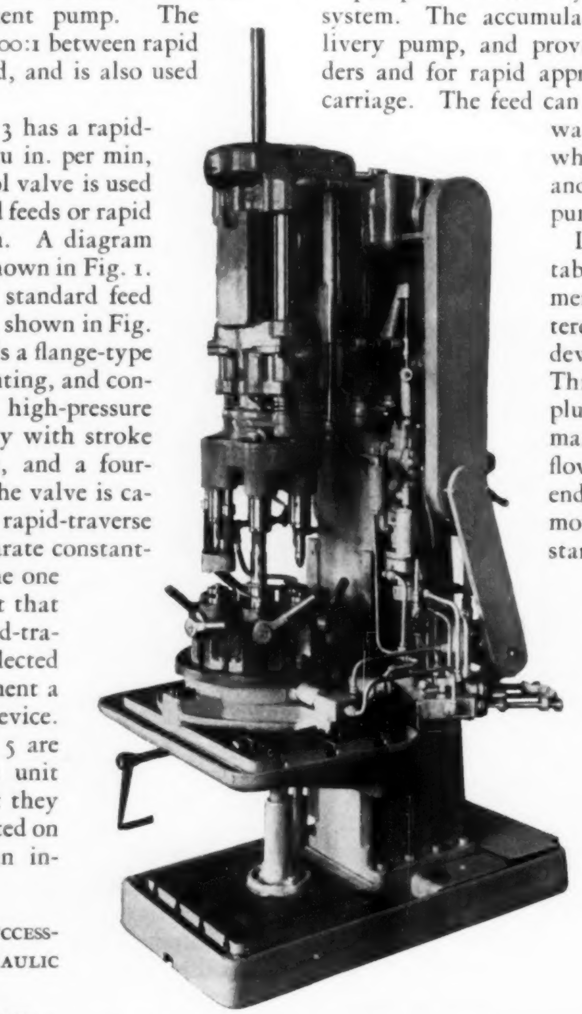


FIG. 6 AUTOMATIC DRILLING MACHINE WITH HYDRAULICALLY OPERATED INDEXING TABLE

On production reaming machines a variable-delivery pump is successfully combined with an accumulator system. The accumulator is charged by a constant-delivery pump, and provides oil for several clamping cylinders and for rapid approach as well as return of the tool carriage. The feed can be started at any point of the forward stroke by means of a valve which shuts off the accumulator oil and connects the variable-delivery pump only to the feed cylinder.

In a hydraulic shaper-planer the table is driven by a variable-displacement pump through a valve of interesting design which was especially developed for this type of motion. This valve contains three different plungers, one of which acts as the main reversing valve and directs the flow of oil from the pump from one end to the other of a cylinder which moves the table; a second acts as a start-and-stop valve, receiving the flow of oil from the pump and either bypassing it or sending it on to the main reversing-valve plunger above described; a third valve plunger is the pilot, which causes the reversing-valve plunger to move through its entire stroke once the pilot valve has been actuated.

In order to obtain a smooth reversal of a heavy mass with a minimum overtravel, it was found necessary to move the main reversing-valve plunger very rapidly for the first part of this motion in order to decelerate the table promptly, and then to move it more slowly during the second half of its travel in order to accelerate the mass smoothly. The reversing-valve plunger must move at two different rates in each direction. This is accomplished by a pair of chokes which operate only in the pilot circuit controlling the motion of the main reversing valve.

In order to prevent changes in overtravel and in the character of the reversing motion, it was necessary to design the chokes so that they would permit the passage of the same amount of oil irrespective of changes in viscosity due to temperature. Building these three plungers into one valve body resulted in saving a large amount of piping and in making a very convenient and compact unit. It is only necessary to connect the pilot-valve operating stem with a lever which is actuated by dogs on the reciprocating part, and to connect the start-

and-stop-valve plunger with a starting and stopping lever. This plunger is arranged to permit an "inching" motion of the table without adjusting the delivery from the pump.

A great variety of standard and special milling machines are equipped with hydraulic feed. A small variable-delivery pump is used to control the table speed by metering the outflow from the cylinder that moves the table. The power unit contains two other pumps, one to supply the oil which actually pushes the table as fast as the metering pump will allow it to go, and another for rapid-traverse motions. The ability to control the feeding speed has proved valuable in increasing production and in improving the quality of the work done. These machines may be equipped with a device for changing the feeding speed during the cut.

Fig. 7 shows a cold saw on which hydraulic feed is successfully used. The productive possibilities of these machines are far beyond those of the previous design with mechanical feed. In many cases mechanical saws have been converted into hydraulic machines by attaching a cylinder and pump.

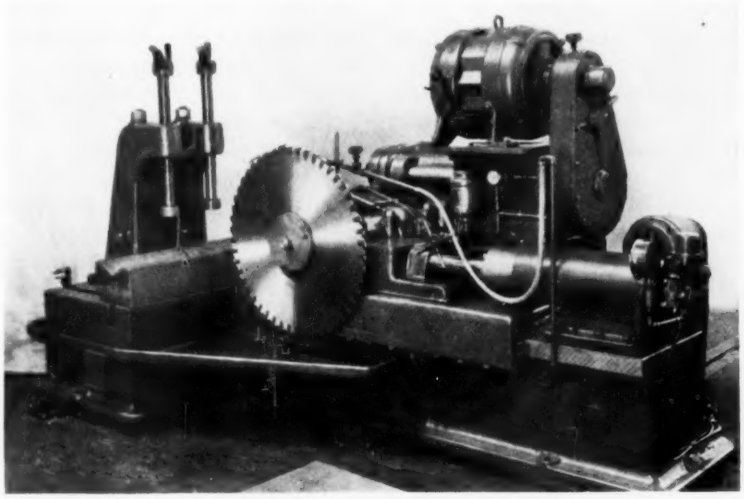


FIG. 7 COLD SAW WITH HYDRAULIC FEED

On the automatic flat-table type of lathe used for production work the movements of the three tool-carrying slides are obtained through a single hydraulic cylinder connected to a variable-displacement pump. The cross-slides are cam-operated from the longitudinal table motion. All feeds are controlled automatically by cams that regulate the amount of oil actually pumped. In the turret-type machine, the volume of oil is regulated for each face of the turret through a series of six cams timed to operate in relation to the six faces of the turret. The cams can be adjusted to give a rapid traverse forward and reverse at any time desired.

Fig. 8 shows an electric butt welder with hydraulic control. In this machine the welding heads are required to advance toward each other very slowly during the arcing, and, when the metal is properly heated, to be forced quickly together. A hydraulic cylinder is attached to the moving head, and a variable-delivery pump is used to control the feed during arcing and the quick push-up. The pump control provides a fine adjustment of the arcing speed, a quick shift to full flow, and a reverse motion for returning the head. On some welders the arcing speed is slowly increased by means of a cam as the metal heats up, and on the largest machines a second constant-delivery pump is thrown in for the final push-up.

In gear-finishing machines completely controlled by a hydraulic unit, a variable-delivery pump is used to drive the table, and a low-pressure cylinder operated from an auxiliary gear pump raises and lowers the head of the machine and locks the machine to the correct finishing dimension while the gear is being finished. The operation is started by the operator and is automatic. The number of strokes, ranging from 1 to 50, depends upon the amount of stock left for the finishing operation. The head of the machine is fed into the gear under a certain pressure so that a gear with excessive stock will not break the cutter or stall the machine. The table stops and the head rises automatically after a predetermined number of strokes.

The hydraulic drives so far installed on paper machines are of two classes:

a Driving individual rolls on a machine otherwise mechanically driven, and

b Complete sectional drive.

The first type is of interest in that it furnishes a convenient means of driving new sections added in connection with the rebuilding of existing machines. It is frequently difficult or impossible to get a mechanical drive to the new rolls on account of interferences with parts of the existing drive and other equipment in the paper mill. By driving the pumping units from the lineshaft the new rolls are held accurately in phase with the old rolls, or can be driven at speeds bearing any desired ratios to the speeds of the other rolls.

In the sectional drive, a hydraulic motor drives each section through a reduction gear. Each motor is driven by a separate pumping unit, to which it is connected by a pair of pipes. The pumps are located at some convenient point out of the way, and are driven by a steam turbine through a single lineshaft which ties them together.

The speed of each section with relation to the other sections is adjusted by changing the displacement of the pump that delivers the oil to the motor driving that section. This is accomplished by electric push-button control from the operating floor. The controls of the pumps are designed to make possible very minute changes in speed. The speed of the entire machine is regulated by changing the speed of the steam turbine that drives the pumps.

Piston valves in the oil lines leading to the motors enable any section to be started and stopped without disturbing its speed adjustment.

The performance of hydraulic drive on paper machines rests on the fact that this drive possesses an inherently stable speed characteristic. The motor at all times attempts to run at the speed established by the flow of oil from the pump, which depends upon the speed of the pump and its displacement setting, and exerts whatever torque may be necessary to carry the driven machine along with it. The motor speed does not, in fact, respond to the rate of oil flow perfectly, owing to the slight leakage. Experience indicates that the small slip introduced by the leakage is beneficial on paper-mill drives, as it prevents building up excessive pull on the paper when the speed settings are not absolutely correct. Preadjusted speeds cannot correspond exactly with the requirements of the paper at all times because of changes in atmospheric conditions and other factors.

When an increase in load occurs on one motor there is a slight decrease in the speed of that motor because of an increase in the leakage from the circuit, owing to the higher operating pressure which results from the higher load. When the load decreases again to its original value, the speed of the hydraulic motor rises to its original value, and *does not rise beyond this value*. (There is in a hydraulic drive no inertia effect analogous to the inductance of an electric motor.)

As each hydraulic motor operates on its own circuit, an increase in pressure in one circuit due to an increase in load has no effect on the pressure in any other circuit; thus, changes in load on one motor have no effect on any other motor.

As contrasted with a hydraulic drive an electric motor must act as a prime mover and also as a governor. The motor is driven by the impressed potential and tends to go first too fast and then too slow, the departures being held within limits by the governing characteristics of the motor. On paper-mill-drive applications external governing devices are also used to reduce the errors in speed resulting from the characteristics of the motors themselves and from voltage fluctuations in the line. The governing elements continually correct the departures from the desired speed after they have occurred, and limit their magnitude. The governor also corrects for the voltage changes mentioned.

Means are provided to simultaneously and proportionately change the delivery from all of the pumps in order to increase or decrease the speed of the entire paper machine. But it is found to be unnecessary to adjust the pump strokes automatically in response to fluctuations in the motor speeds, as sudden fluctuations in speed are not characteristic of a hydraulically driven paper machine.

The development work in the field of power-transmission hydraulics has continued actively throughout the last five years. In the larger units, efficiencies and durability have been greatly improved. In the smaller units designed for performing the various functions involved in machine-tool feeds and other types of work where repeated sequences of motions are required, the developments have been characterized by improved designs accomplishing ever more difficult tasks by means of simpler and more compact equipment.

As an example of this, a multiple-plunger variable-delivery pumping unit of 4.6 cu in. displacement which in 1927 was capable of being run continuously at 1250 lb pressure, giving a continuous output rating of about 11 hp, has been developed without change in basic design until it will now carry exactly twice the pressure and deliver twice the power on the same rating basis. In fact, the durability of the unit at the higher pressure is greater than it was at the lower pressure five years ago.

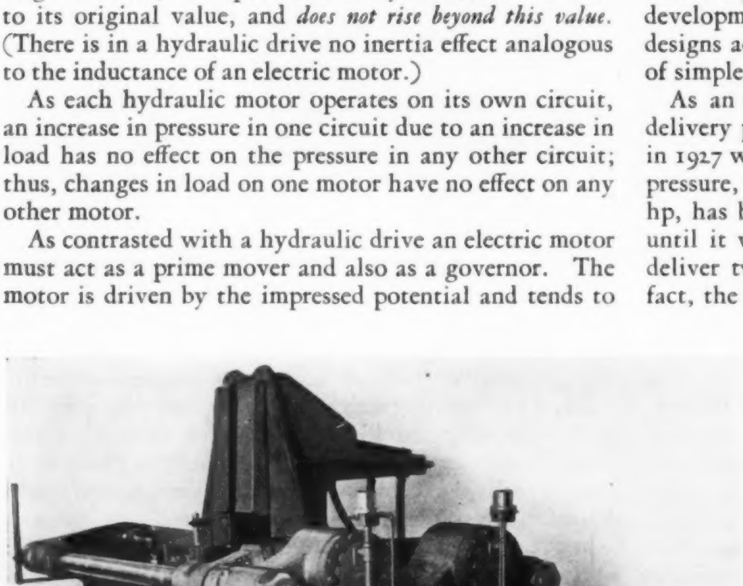


FIG. 8 750-KVA ELECTRIC BUTT WELDER WITH HYDRAULIC TABLE DRIVE

These new high-pressure pump units are capable of continuous operation at 2250 lb per sq in., and over short periods of time at 2750 lb. They open up new possibilities for the use of hydraulic equipment of the volumetric type on hydraulic presses and other machines where it is desirable to use cylinders of small size. Hitherto units capable of these pressures have had to be used in such a manner that the pump operated under full pressure for only very short periods of time.

Valves of various types are available for use in connection with these high-pressure pumps. It is no longer necessary to use poppet-type or packed valves, as piston-type valves with no wearing parts are now being produced for use at pressures up to 3000 lb per sq in. Variable-stroke pump and motor units have been developed that are considerably more compact than the units hitherto available.

The Trend of

MOTOR-CAR DESIGN[1]

By WILLIAM G. WALL[2]

BEFORE attempting to predict the trend of motor-car design, let us first look briefly at the car of today. The 1932 motor cars, in spite of a number of unnecessary "gadgets," show considerable engineering thought and some progress. The increase in the number of cylinders has become necessary, as will be shown later. Free wheeling has been adopted to meet a popular demand, and has the advantage of easy gear shifting, obtained otherwise only by synchro-mesh design. Placing the free-wheeling clutch, roller or spring type, at the rear of the transmission, so as to act on all speeds, has been an improvement. But while free wheeling has improved the gasoline economy, it has also increased the wear on brake linings.

Although the synchro-mesh transmission has been used for a considerable time, it has recently gained ground rapidly and is without doubt the greatest advance in transmission construction that has been made for a number of years; with the use of constant-mesh gears it has made the sliding-gear type of transmission a logical piece of mechanism.

The use of the automatic clutch control, either of the vacuum or centrifugal type, for throwing out the clutch, is comparatively new, although the idea has been in the experimental stage for some time. The vacuum arrangement apparently has worked out better, though the centrifugal-force type is in principle somewhat simpler.

International Newsreel

ONE OF THE NEW "AIR WHEELS" (RIGHT) COMPARED WITH THE STANDARD TIRE (LEFT) IT REPLACES

The "ride control" or dash adjustment for hydraulic shock absorbers has become quite popular.

Rubber mountings for the engine are being used on most cars as they provide a very simple means of reducing vibration, which latter is partly due to poor workmanship and partly to the inability of designers to eliminate the trouble at its source.

"Floating" the engine on pivots at the front of the engine and rear of the transmission, with springs to take up the inequality in torque reaction, is a good idea, although not new, as a somewhat similar method was patented in 1905. The principal difference is that no rubber was then used. It must be said in this case that the use of rubber has very materially helped in the solution.

There has been a jump to stiffer frames, and especially to the use of the X cross-member, which was first brought out in motor cars about seven years ago. This has become necessary because engines are now more flexibly mounted and therefore do not help to brace the frame.

The insulation of the bodies, especially the dash, floor boards, and cowls, from the heat and noise of the engine is one of the greatest improvements ever made for the comfort of the passengers.

The use of safety glass has materially increased, and is a very important consideration in the safety of a car.

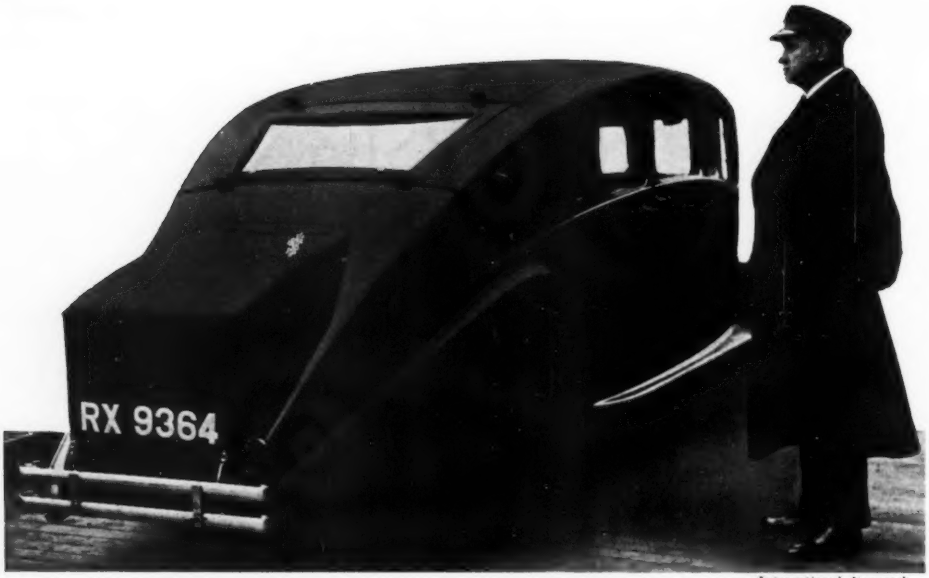
Outrigger mounting of body sills on the outside of the frame seems to be coming back into favor.

The use of bolts instead of wood screws for holding together the body frame, and the welding of steel panels, assist materially in making the bodies both stiffer and more durable.

It is impossible in a short article like this to go into a discussion of all the new or late ideas, so only a few

[1] In connection with the present article, the reader may profitably refer to Colonel Wall's paper, "Engineering Problems of Modern Motor Cars," presented at the French Lick, Ind., meeting of the A.S.M.E., Oct. 13–15, 1930, and published in Mechanical Engineering, December, 1930, pp. 1070–1074; and also to a brief review of the more important features of the cars exhibited at the National Automobile Show this year, which appeared in Mechanical Engineering of March last, on p. 230.

[2] Consulting Engineer, Indianapolis, Ind. Mem. A.S.M.E.



International Newsreel

STREAMLINE AUTOMOBILE BODY DESIGNED BY SIR DENNISTOUN BURNEY, BUILDER OF THE BRITISH AIRSHIP "R-100"

of them will be mentioned. Among these are oil coolers, using water from the radiator as the cooling medium.

Others are brake drums of better material, especially those lined with cast iron and comparatively inexpensive, such as the "centrifuse" type. The cast-iron drum has always had the best wearing qualities, but has been too expensive and rather heavy. The use of hydraulic brakes has not materially increased. Vacuum spark control for retarding the spark when the throttle is closed has appeared, as has also unequal spacing of fan blades, this latter being supposed to eliminate noise and vibration, though there seems to be quite a difference of opinion in regard to how much it accomplishes in these respects.

The use of oil and air filters continues, though both of these, especially the oil filter, are still inefficient. It would be difficult to get under the hood an oil filter that was sufficiently large to be efficient.

While the air filter probably does remove a small amount of dust from the air, the types that are most effective are those in which the air is drawn through oil. The air filter, however, is useful as a silencer for the noises in the carburetor and manifold.

The "Startix," for starting an engine when the ignition is turned on, and to prevent stalling, is a useful device, especially for the novice. However, it can only be used with a special make of starter drive.

Kick shackles for front springs have increased in use, but, while reasonably effective, they are not an infallible remedy for wheel and axle shimmy.

ENGINES

The increase in the number of cylinders in the engine, with the quick jump from six to eight in the smaller cars and from eight to twelve or sixteen in the larger ones, is the inevitable result of the demand for more power and therefore for larger engines. While the controversy which has raged for so many years regarding the relative advantages of low-speed and high-speed engines has been goingon, speeds have so increased that today a large percentage of passenger-car engines run as high as 3500 rpm and some 5000, so that from the standpoint of even ten years ago they are all high-speed; and even bus and truck engines have gone up in speed considerably.

These higher-speed engines require lighter reciprocating parts, which can only be had by keeping the size of the cylinder small, thus allowing the use of light pistons, rods, and valves, and also higher compression. To do this and to get the greater power and torque, it was necessary to increase the number of cylinders. For engines above 125 hp the 12-cylinder arrangement, especially for passenger cars, seems the most logical, as the double six has a number of inherent advantages. Two motor-car manufacturers thought this back in 1914, but as car owners at that time were demanding neither such startling performance nor so much power as they are now, there was no necessity then for the larger number of cylinders. As more power is demanded and the size of engines increases we shall probably have more of them with 16 cylinders. Heavy-duty 12-cylinder engines are coming rapidly into use for buses and trucks, as well as for passenger cars.

Most of the 12-cylinder V-engines have equally spaced explosions, obtained by using a 60-deg angle between the blocks, but some have a much greater angle, 80 deg, and others a much smaller one, 30 deg. The primary object of unequal spacing is to eliminate synchronous vibration, but there is a great advantage in employing the smaller angle as it makes possible a more compact and therefore lighter engine.

The use of counterweighted crankshafts has increased and has helped materially in eliminating the high main-bearing pressures which would have resulted from the greater power and the desire to limit the length of the engine.

The use of a larger-bore and shorter-stroke or nearly "square" engine, which has been the general trend for several years, has the advantage of making the engine lighter, and the use of the multiple-cylinder V has eliminated the necessity of making the engine longer, which would obviously have followed with the larger bores resulting from making the engine "square."

The use of duplex carburetors has increased to a certain extent, especially on eight-cylinder engines, as with the dual type it is simpler to get a more equal distribution by using a double manifold, one for each four cylinders.

The downdraft carburetor probably results in the development of no more power than the updraft, but it has the advantage of being out of the way and subject to less of the heavy road dust, and makes starting easier.

The use of aluminum pistons has increased somewhat, though it cannot be said that any great improvement has been made in them during the past year. Most cast-iron pistons are now tin-coated, which helps materially in reducing the scoring of the cylinders during the wearing-in stage. Most cylinders are now being made of a chromium or nickel iron, or of an alloyed semi-steel.

Very little has been done on valve seats for passenger-car engines, excepting possibly an improvement in conducting the heat from the head of the valve by the use of inserted copper-cored valve stems. A few are using 30-deg seats, though 45-deg seats are still more popular. Inserted valve seats have helped greatly to eliminate one of the main troubles with bus or truck engines. One of the best and most durable of these consists of an inserted steel ring with a seat of stellite welded on the ring. Several other types of inserted seats are also being used, and in aluminum heads with valve-in-head engines, aluminum-bronze seats are used.

The use of dampers, either of the Lanchester, harmonic, or rubber type, has increased somewhat, although there seems to be no great necessity for a damper on a 12-cylinder engine if the crankshaft is properly designed.

The thickness of the babbitting of rods and bearing shells is continuing to decrease, especially where cost is of no great consequence. Some years ago a $^1/_8$-in. thickness of babbitt was not considered excessive; today however, an endeavor is made to keep this thickness down to $^1/_{64}$-in., and even thinner babbitt would be desirable, especially in the rods, if it were not so expensive to produce. Some steel rods are now being used with inserted thin babbitted shells; these are less expensive than babbitting the rod direct, and in addition are very easily replaced.

The number of tractor trucks with semi-trailers is rapidly increasing. On account of recent legislation limiting the overall length of trucks, tractors, and trailers, these trucks are now being made with a very short wheelbase.

No passenger cars are as yet using power steering, though considerable experimental work of this nature was done several years ago, but some of the larger buses and trucks are using a power-type hydraulic steering gear.

LOOKING BACK A FEW YEARS

A number of the designs and supposed improvements of the last three or four years have not proved permanent, and others have made very little if any headway.

The front-wheel drive might be taken as one of the best examples of this, although a year or so ago several manufacturers, besides the two then producing them, had designs either drawn up or else had cars running in the experimental stage and ready for production. Only one American car now uses the front drive.

The four-speed transmission for passenger cars, though still used, has lost ground. The only substitute which has appeared is the dual-ratio rear axle, used on one of the new cars.

International Newsreel

THE ENGINE OF SIR DENNISTOUN BURNEY'S CAR IS LOCATED IN THE REAR

The worm-drive rear axle has made little headway, only two passenger cars using it, though the device is fundamentally sound.

Some years ago several different one-shot oiling systems for chassis appeared to have a wide field, but in place of increasing in use, they have decreased very materially. Regardless of this, the oiling of the chassis has been very much improved.

The use of forged aluminum-alloy rods has not increased. Superchargers, which threatened to come into vogue several years ago, are no longer heard of except on certain racing cars, though the maker of one American air-cooled car states that a supercharging effect is provided by the cooling fan.

The solid rubber block that was used at the ends of the springs in place of shackles seems to be gradually disappearing, as few are now being used.

The multiple-disk clutch, which was so popular a few years ago, has almost disappeared. The single-plate is the most popular, though the dual and even three-plate are used on some heavy-duty engines.

The vacuum tank for fuel supply which was used on nearly all makes of cars until the last two or three years, is being replaced on most cars by the fuel pump, which takes up less room and gives better results, especially at high engine speeds.

Disk wheels are now practically out of the picture for passenger cars, and not so many wood wheels are being used.

FUTURE POSSIBILITIES

The discussion thus far has considered a few of the many new and some of the old ideas which have appeared in motor-car design, but what engineers are most interested in is the design of the future.

Within the next two years we shall see a very different car from what we now have, since a number of the ideas with which automobile engineers are now experimenting will then be in production.

Among these innovations will be individually or separately sprung wheels. This change is of great importance and will come rapidly, not only on passenger cars but also on buses and trucks. It reduces the unsprung weight and greatly improves a car's riding qualities. Some forms of separately sprung wheels have been used abroad, but the new ways in which this springing is effected are a great improvement over the old ones.

STREAMLINE DESIGN FOR CAR BODIES

Streamline design for car bodies is rapidly coming to the front, and future cars will probably have a fairly blunt nose and a long, tapering tail. Some of the cars recently designed by Sir Dennistoun Burney are the extreme in this regard, and also have the engines in the rear.

This placing of the engine in the rear of the car instead of in front is now being widely discussed. There are a number of things to be said both for and against the idea. For motor buses it has a number of advantages and very few disadvantages, while for passenger cars it assists the designer of the body in bringing out the aerodynamic qualities of a vehicle.

The principal advantage, aside from ease in streamlining the body, is that the passengers are not placed over or back of the rear axle, which is generally the hardest riding position in the car. Placing the engine in the rear gives better road visibility and improves the riding qualities materially; further, the noise from the engine is less objectionable.

The disadvantages seem to be that it is difficult to make proper transmission and driving connections, and that the engine, being directly behind the passengers, might be hurled forward in case of collision. Also when traveling at high speed, with the weight of the engine so far back of the center of pressure, especially in the teardrop variety of streamlined bodies, there would be difficulty in keeping on the road in the case of a strong cross-wind, as this is difficult enough now with some of our present cars.

Some of the new fighting tanks have the engine in the rear in a separate compartment, and when the engine is water cooled, the method employed is that of sweeping the air down from the top of the engine compartment, through the radiator, and out again at the top. This arrangement also gives the driver better visibility and keeps the heat of the engine out of the turret part of the tank; consequently there is no great problem involved in cooling an engine when placed in the rear in a passenger car.

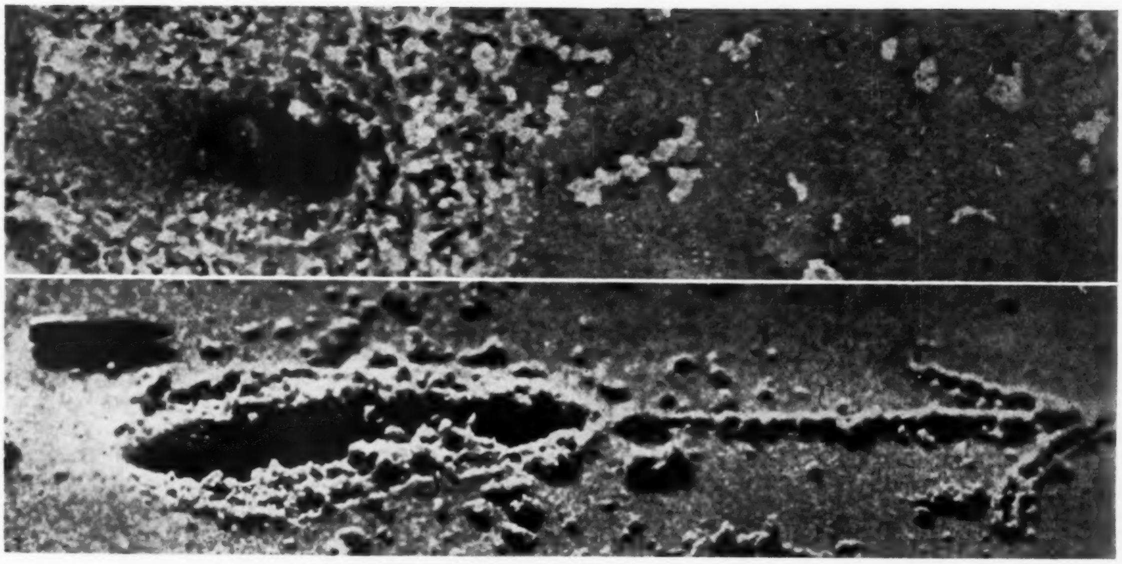
In the future the transmission will probably be located close to the rear axle, and attached to the frame by means of DeDion-type double-universal-joint driving axles, whether the engine is at the front or rear. One bus manufacturer has recently brought out a rear axle of this type. There is some objection to this in passenger cars because the tread is comparatively narrow, generally not over 60 in., which results in a considerable angle in the drives of these axles. The advantages of this design, however, more than balance this one objection. There is no such disadvantage in motor-bus work where the tread can be wide and where the outside width can be up to 96 in.

Battery ignition with the ordinary distributer has always been difficult at extremely high circuit-breaker speeds, so that considerable thought is now being given to using some of the new designs of magnetos, which would help at the higher speeds but probably not be so satisfactory at extremely low ones.

THE NEW AIR WHEELS

A number of years ago when balloon tires were first brought out, it was difficult to get manufacturers to adopt them because they looked so large. The public at first did not take to them, and exhibited the same hesitancy that they had in previous years in changing from solid to pneumatic tires. Now come the new air wheels, which consist only of a hub and tire under very low pressure. It is difficult to design brakes for these wheels, and tests seem to have shown that, as would

(*Continued on page 497*)



IMPACT IN HARD SAND OF M1906- AND M1-TYPE BULLETS

[Upper view shows M1906 partly buried (range, 2400 yd). Lower view shows mark left in sand (range, 4800 yd) as M1 ricochets in direction indicated by arrow. M1 bullet shown is for comparison.]

BULLET DEVELOPMENT—ACCURACY *and* RANGE

A Century of Progress—Remarkable Results Obtained in the Last Decade by the Ordnance Department of the U. S. Army

By GLENN P. WILHELM[1]

ONE hundred years ago the standard military smooth-bore musket of the United States Army could just be depended upon to hit a man at 100 yd. Today a man can be hit at 1000 yd as easily as he could be 100 years ago at 100 yd. The modern sniper with a telescopic sight and special ammunition can hit a man with reasonable certainty under favorable conditions at 1500 yd. Therefore the accuracy and range have increased so that now at ten to fifteen times the former distance the same target can be hit with equal certainty.

One hundred years ago the standard military smooth-bore musket of the United States Army required a circle about three feet in diameter in order to include every shot of ten consecutive rounds at 100 yd. Today the diameter of this circle is about three inches, and cases are known where all shots of a ten-round group at 100 yd apparently passed through the same shot hole. Such groups are rare, but not much more so than the three-foot, ten-shot group of 100 years ago.

One hundred years ago the penetration of the standard military musket at 100 yd in oak was insufficient to bury the ball. Today, at 100 yd, under the same conditions, the penetration is about fifty times as great.

One hundred years ago a rifleman fired one shot every two minutes. Today, with the latest type of semi-automatic rifle developed by the Ordnance Department of the U. S. Army, it is possible to fire over one hundred times as rapidly.

The eyes and the physical make-up of the rifleman of today are probably little, if any, superior to those of the rifleman of one hundred years ago. In training and mechanical intelligence the marksman of today is of course far superior. The three primary considerations for the remarkable strides of the last century have been the perfection of the weapon, particularly the barrel and sights, the perfection of the ammunition, and the training of the man who pulls the trigger.

A REVIEW OF THE PAST

In this article the discussion will be limited, so far as modern development is concerned, to the ammunition, and chiefly to bullets; and in order that present-day accuracy and range may be appreciated, the past will be briefly reviewed.

In the glorious days of ancient Rome and Carthage, slingers

---

[1] Major, Ordnance Dept., U. S. A., Washington, D. C.

NOTE: In the present article the author has borrowed somewhat from his articles in the *American Rifleman*, of September 1 and 15, 1925, on "The Evolution of Accuracy and Range," and in *Army Ordnance*, March-April, 1925, on "Modern Small Arms and Their Uses."

and archers were trained by starvation methods to develop an uncanny ability to hit the most minute of objects at a few paces. In the centuries that followed such skill appears to have been lost, but at the time of the battle of Crécy (1346), when gunpowder is said to have first played a decisive part in battle, the English archer possessed a degree of skill at distances as great as 200 paces which was not equaled by the new weapon (the gun) until at least several centuries later.

Omitting from consideration the rifles used by the early American backwoodsmen, Kentucky riflemen, plainsmen, and mountain men, whose feats were greatly exaggerated, there was no standard weapon developed which in the terms of present-day knowledge could be said to possess accuracy to any degree until rifled muskets came into general use in the military service to replace the old smooth-bores. Prior to the Civil War, from a military standpoint, firing at ranges beyond about 150 yd was a loss of time and ammunition. The only kinds of target practice indulged in by troops consisted in firing blank cartridges to accustom them to the sound and recoil and to teach them to hold the musket horizontally from the shoulder, point it toward the ranks of the enemy, and fire at command.

During the decade comprising the Civil War, about the greatest accuracy possessed by military rifles would have been that of firing ten shots at 1000 yd into a circle somewhere around 200 in. in diameter. (Firing at such ranges was not practicable. This distance has been chosen for comparison with later times.) In the following 20 years the accuracy had improved to the extent that a circle of about one-half that diameter would contain the same number of shots at the same range; and, omitting from consideration match rifles, along about 1890, military rifles and their ammunition began to give improved results by reason of intensive investigations conducted by the different military powers.

IMPORTANCE OF SHAPE OF BULLET

Since the introduction of smokeless powder the flight of bullets has been revolutionized by two changes in their design. These are the general use of the sharply pointed "Spitzer" type of bullet and the "boat-tail" bullet. Contrary to the general belief, both types made their appearance at the same time, and the credit for these remarkable improvements belongs to the French, who, as a result of their experimental work carried on during the years 1894–1897, introduced in 1898 the justly famous "Balle D," which is both a pointed bullet and a boat-tail bullet. Technically, this was a change from old types of blunt-nose, cylindrical-body, square-base bullets to the World War French type, bi-ogival, M1898 Balle D. This bullet, with slight modifications, was used in the World War by French rifles and machine guns, and by American forces when armed with the French Hotchkiss machine gun. The ordinary boat-tail bullet is one which normally is pointed in front but tapered at the base, the taper stopping considerably short of a point and ending in a flat or cone-shaped cup. It is sometimes called a streamline bullet, but even this name is misleading, in that the projectile is not streamlined like an airplane strut, which is quite blunt in front.

Due to the fact that, prior to the World War, small-arms firing at ranges beyond 1000 yd was considered impracticable, other nations failed to profit by the French experiments, which, incidentally, were conducted at ranges of 1800 yd. The virtues of the tapered-base bullet are chiefly apparent at ranges beyond 1000 yd, while the reverse is true of bullets which have flat bases and sharp points, as the latter are most effective at the shorter ranges. The reason for this, which is now well known although not so apparent then, is because air resistance at velocities beyond that of sound (1100 fps) operates chiefly on the forward portion of the bullet, while at velocities below that of sound the major resistance encountered is at the rear, due to the vacuum. Shaping a *high*-velocity bullet like an airplane strut, i.e., blunt in front and pointed in the rear, is of no avail. Such a bullet must have a reasonably sharp point in front to literally "split" the air. Since the vacuum extends around the entire rear portion, as the velocity drops the air closes around the base, and if the base is tapered the vacuum is materially reduced. If the bullet is flat-based, the vacuum extends over the whole base.

Apparently military investigators, except the French, due to short-range firings, devoted their time and attention to the point of the bullet, so that when Germany came out with the pointed bullet in 1904, practically all the military powers followed suit, the United States adopting in 1906 a similar pointed bullet, known as the Model 1906. This bullet has been used by us up to the present time, but the ammunition now being made for war reserve, although of the same exterior dimensions, has a pointed front with a boat-tail base. This cartridge is known as M1, and will be in general use by the U. S. Army as soon as the stocks of Model 1906 are exhausted. This, it is expected, will happen within the next year or so.

EVOLUTION OF THE M1 BULLET FROM THE M1906

The evolution from the M1906 bullet to the M1 can best be traced by reference to the World War and our national rifle matches. In the World War the French Hotchkiss machine gun with the Balle D type of bullet (muzzle velocity, 2400 fps; weight, 198 grains), previously mentioned, so far outranged the German flat-base bullet (muzzle velocity, 2900 fps; weight, 154 grains) that the Germans in the latter phase of the war came out with a long-range machine-gun type of ammunition similar to that of the French. The results of the experience our troops had with the French Hotchkiss caused them to insist on having the range of their new Browning machine gun, which used the M1906 bullet—similar to the standard German 154-grain bullet, increased to correspond to that of the latest German long-range machine-gun ammunition, which had been patterned after the Balle D.

Experiments were therefore conducted in this country at long ranges to obtain data necessary for the increased range, as it was not desired to copy the French bullet, which possessed a number of disadvantages such as inaccuracy and lack of velocity for armor-piercing types of ammunition, and increased difficulties from a procurement standpoint.

These firings showed that a pointed bullet with a boat-tail base, similar to the bullet the Swiss used in the 300-meter international matches in this country in 1913, and which incidentally were won by the Swiss, gave the greatest range. In this connection, it is understood that at the time the Swiss were not aware of the long range of which their type of bullet was capable.

It was a difficult problem to make a bullet which would fit the mechanism and barrels of our vast reserve stocks of rifles and machine guns, and yet would give improved accuracy and long range. However, by utilizing the national rifle matches as proving-ground tests, and by making slight changes at a time, it was possible to progress from the M1906 to the new M1 type of ammunition, while at the same time greatly increasing the accuracy and nearly doubling the range. The chief factor resulting in the increased accuracy, flatness of trajectory, and range was found to be the shape of the bullet.

BALLISTIC COMPARISON OF M1906 AND M1 AMMUNITION

The flatness of trajectory of the M1 ammunition as compared

with that of the M1906 is shown by the data of Table 1.

On hard sand the M1906 partly penetrates without ricocheting at 2400 yd, while the M1 will ricochet at 4800 yd.

While the boat-tail bullet has all the advantages when once in flight, not only is it more difficult to manufacture and procure, as it requires more operations and greater care, but it has one inherent drawback—it does not seal powder gases as well in the bore as does the flat-base bullet, and thus the barrel erosion is greater. Not only has the flat-base bullet a larger bearing to assist in sealing the barrel, but the flat base tends to upset under pressure of the gases, which prevents gas leakage. On the other hand, the tapered base of the boat-tail projectile allows room for more powder in the case, which, together with decreased friction due to lack of bearing, gives it a higher velocity, other things being equal.

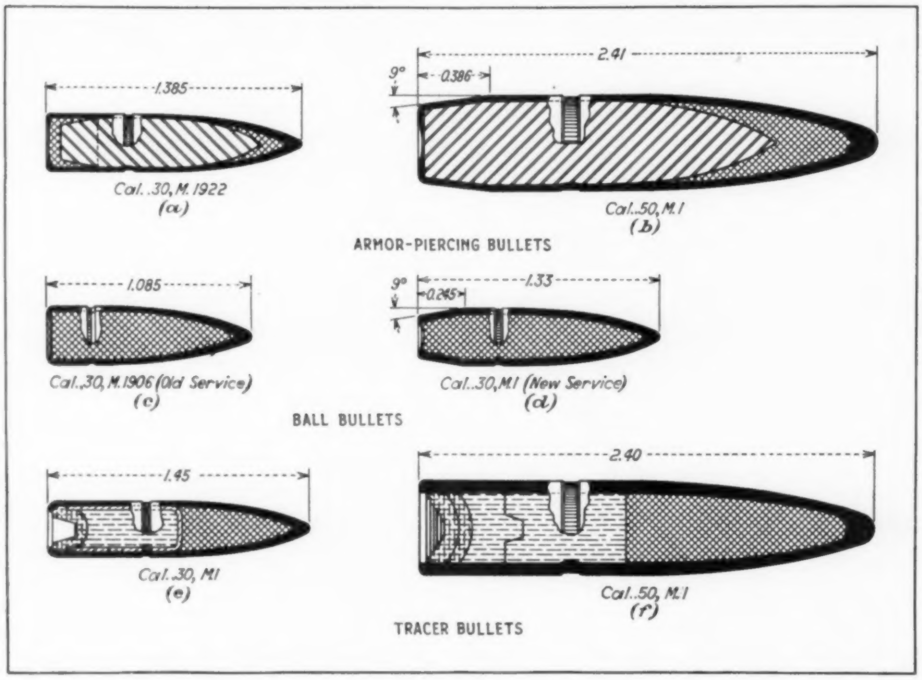


FIG. 1 CALIBER .30 AND CALIBER .50 BULLETS

(a) Weight, 168 grains; gilding-metal jacket, tungsten-steel core, lead and antimony base filler and point filler.
(b) Weight, 752 grains; gilding-metal jacket, tungsten-steel core, lead and antimony point filler.
(c) Weight, 150 grains; cupro-nickel jacket, lead and antimony slug.
(d) Weight, 173 grains; gilding-metal jacket, lead and antimony slug.
(e) Weight, 154 grains; gilding-metal jacket and composition container, lead and antimony slug, tracer composition.
(f) Weight, 674.5 grains; gilding-metal jacket, lead and antimony slug, tracer composition.

NATIONAL RIFLE MATCHES AND AMMUNITION DEVELOPMENTS

Since the adoption of M1906 ammunition the development of improved accuracy and range for small-arms ammunition can also be seen by reference to the records made at our national rifle matches which are held annually at Camp Perry, Ohio. In the most important of these matches, standard service rifles and ammunition are used.

TABLE 1 BALLISTIC DATA FOR U. S. CALIBER .30 AMMUNITION

(Muzzle velocity, 2700 ft per sec)

Range, yards	Angle of elevation M1906	Angle of elevation M1	Maximum ordinate, feet M1906	Maximum ordinate, feet M1
500	16′	14′	2.0	1.8
1000	49′	38′	15.3	10.5
1500	1° 57′	1° 21′	61.0	39.0
2000	3° 54′	2° 25′	176.4	99.0
2500	7° 12′	3° 47′	412.2	192.0
3000	13° 30′	5° 33′	961.2	342.0

During the World War the matches were suspended, but when the experience of that conflict necessitated a new type of service ammunition with greatly increased range and accuracy, restrictions on the use of service ammunition at the national matches were removed. The last matches using M1906 ammunition were those of 1919. Various types of ammunition, differing chiefly in the bullets used, were tried during the years 1920–1925, resulting in the perfection of the present improved M1 type.

In order to compare accuracy, an explanation of the means of comparison is in order. The two figures most generally used are measurements known as the "mean radius" and the "extreme vertical." The mean radius, in effect, is the mean deviation of a group of shots from the center of impact. It is the hypothenuse of a right-angled triangle, the sides of which are the mean horizontal and mean vertical deviations. Mathematically, it may also be defined as the square root of the sum of the squares of the mean horizontal and mean vertical deviations. The extreme vertical is the vertical distance from the highest to the lowest shot of a group. A target or group usually consists of ten shots, and enough targets are obtained to secure a fair average. The tests were formerly carried out with selected rifles fired in a mechanical device known as a machine rest. Since the war the firing has been done with heavy cylindrical barrels with concentric rings placed in a V-shaped steel trough. The barrels have actions but no stocks.

Considering national-match ammunition, the wartime specifications of the M1906 ammunition corresponded, at a range of 1000 yd, to a mean radius of about 22 in. and an extreme vertical of about 65 in. Selected lots of this ammunition, used in the 1919 national matches, gave a mean radius, at 1000 yd, of 9.65 in. and an extreme vertical of 28.21 in.

By 1921 the national-match types of ammunition had improved to the extent that the mean radius was 8.52 in. and the extreme vertical 22.87 in. The culmination of the development was reached in the 1925 national-match ammunition, with a mean radius of 5.7 in. and an extreme vertical of 17.08 in.

Subsequent to 1925 there were only two years in which the standard M1 ammunition was not used as national-match ammunition, although even then the principal components were selected M1 types. In the years 1929–1930, the M1 type of bullet was used. In 1929, the average mean radius

was 5.69 in., with an extreme vertical of 17.63 in. The ten best targets gave a mean radius of 4.17 in. and an extreme vertical of 11.35 in. In 1930 the average mean radius was 5.15 in. and the extreme vertical 15.92 in., while the 12 best targets gave a mean radius of 4.25 in. and an extreme vertical of 12.38 in. With the latter ammunition difficulty was experienced in the preliminary matches owing to pierced primers, as a type of primer known as the "Berdan" was used. Another lot with standard primers was substituted, not so accurate but more reliable in its action. The lack of accuracy was not necessarily the fault of the standard primer, as the most accurate ammunition ever made (special match), as will be shown presently, was made with this primer. The ammunition which was superseded was the most accurate national-match ammunition ever produced, and, of course, was a production job, the same as all national-match ammunition.

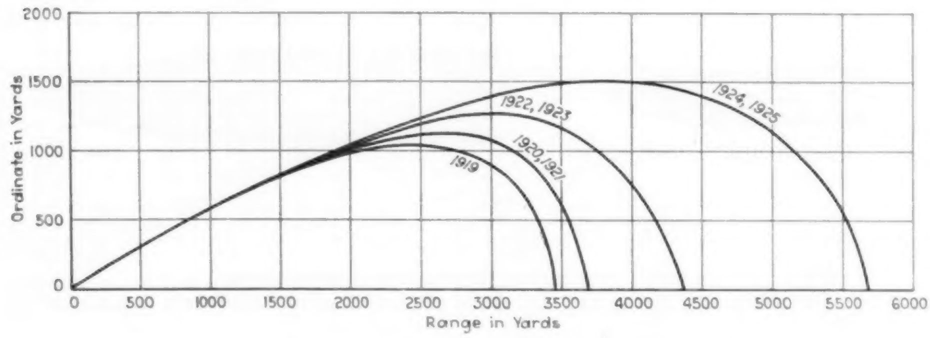


FIG. 2 TRAJECTORIES OF NATIONAL-MATCH BULLETS

(Caliber .30, fired at angle of 30 deg. Bullets: 1919, Service 150-grain flat base; 1920–1921, N.M. 170-grain flat base; 1922–1923, N.M. 170-grain 6-deg flat-base; 1924–1925, N.M. (New Service) 172-grain 9-deg boat-tail.)

The extreme ranges of the types of ammunition used in the 1919, 1921, and 1925 matches were as follows:

1919 National Match (M1906)	3400 yd, approx.
1921 National Match	3700 yd, approx.
1925 National Match (M1)	5700 yd, approx.

The difference in the bullets—and this was the major change in the types of ammunition—consisted in the 1921 bullet's weighing 170 grains instead of 150 grains, which was the weight of the M1906 (the shape otherwise being the same), and the 1925 bullet's weighing about 172 grains, but with a tapered boat-tail base. This 1925 ammunition, with minor modifications, is the new M1. Of course, there were several intermediate steps in which the same or different types of ammunition were used during the intervening matches.

If we consider special-match ammunition, which are types not made on a production basis, and which are used in international, Olympic, and Palma-type matches,[2] we shall find the various steps somewhat as follows:

The international match is fired at 300 meters, and in the tests to adopt an ammunition for the 1912 matches the mean radius of the winning ammunition corresponded to 2 in. In 1920 it was approximately 1.6 in., while in 1925 it was 0.85 in. The type of bullet used varied from 180-grain flat-base bullets for 1912 and 1920, to the M1 boat-tail type for 1925. The Palma matches and certain of the Olympic matches use a range of 1000 yd. In 1909 the accuracy of the 180-grain flat-base bullet, adopted by test for the matches, corresponded to a mean radius of 8.36 in.; in 1921 it was 6.04 in., and in 1925, 4.43 in. In the latter case the 16 targets comprising the last day's firing gave the remarkable mean radius of 3.97 in. This corresponds to an extreme vertical of 11.32 in. The average extreme vertical of the 19 best targets was 10.53, while their average mean radius, all of the radii being under 4 in., was 3.57 in. These figures, so far as the author is aware, are the best that have ever been obtained by any nation, and probably will not be excelled for some time to come. In this connection individual targets of 10 shots have been obtained at ranges of 300, 600, and 1000 yd, in which the diameters of the circles which would contain all shots were 2, 4, and 6 in., respectively.

A flat-base type of bullet similar to the national-match types was used for all the special matches up to and including 1921. The M1 type was used in 1925.

Before the World War, armor-piercing and tracer ammunition were unknown. The usual bullet, such as the M1906 or M1, consisting of a lead core and a copper-alloy jacket, will penetrate many varieties of mild steel about half an inch at 100 yd. Against armor plate, however, it flattens as if it were made of soft lead.

ARMOR-PIERCING AMMUNITION

Armor-piercing ammunition of calibers .30 and .50 is manufactured for use against armor plate with which airplanes, tanks, and other vehicles of war are equipped. The caliber .30 armor-piercing cartridge, M1922, was adopted after an exhaustive series of experiments with practically all known types of alloy steel, including many series of heat treatment. The profile of this cartridge is the same as that of the standard ball cartridge (M1906 or M1), and, with the exception of the bullet, all components are identical. The armor-piercing bullet weighs 168 grains and consists of four parts, the gilding-metal jacket or outer case, the chrome-tungsten-steel core, and the hardened-lead point and base fillers. The steel core has a cylindrical center section, an ogival or pointed nose, and a tapered base. At present the muzzle velocity of this bullet is 2647 ft per sec, which is the same as that of the standard ball. However, consideration is being given to increasing its velocity as much as possible within the limits of safe chamber pressures. The maximum range is approximately 3550 yd. The bullet will penetrate armor plate $^1/_4$ in. thick at 500 yd, or $^1/_2$ in. thick at 100 yd.

The caliber .50 M1 armor-piercing bullet is made of the same materials and is a counterpart of the caliber .30, with the exception that in the larger caliber the lead base filler is omitted and the jacket has a taper base conforming to the taper base of the core. The assembled bullet weighs 753 grains, the jacket 263 grains, the steel core 408 grains, and the point filler 81 grains. The muzzle velocity is approximately 2500 ft per sec, and the maximum range is approximately 7200 yd. This bullet will penetrate armor plate 1 in. thick at ranges of 100 yd, and $^1/_2$ in. at ranges of 1000 yd.

The caliber .30 armor-piercing bullet was made flat-based in order to give the maximum barrel life by providing the best possible sealing of the bore against powder-gas leakage.

[2] These matches are sometimes fired at Camp Perry, and sometimes in foreign countries.

Long range was not essential in this bullet, and since armor-piercing bullets produce more wear on barrels than do ball ammunition, it was decided to retain the flat-base-shaped bullet. On the other hand, in the caliber .50 long range was essential, and the bullet was therefore made boat-tailed.

It will also be noted that the caliber .50 ball is the same as the caliber .50 armor-piercing, the only difference being that the steel core of the ball is of mild steel, not heat treated, while the armor-piercing bullet has a tungsten-steel core, heat treated. By keeping the components the same, the ballistics for the two bullets are similar.

TRACER AMMUNITION

One of the simplest and most effective methods of directing machine-gun fire against aerial targets is that of firing tracer ammunition interspersed with ball or armor-piercing ammunition. The bullet of the tracer cartridge contains an inflammable mixture composed chiefly of strontium peroxide, strontium nitrate, and magnesium, which becomes ignited by the powder gases when the cartridge is fired, and burns with a bright red flame throughout a portion of its flight. The early trajectory or path of the tracer closely approximates that of the ball bullet, and thus by observing its travel it is possible for the gunner to follow the direction of the cone of his fire and adjust it to the movements of the target. The tracer cartridge, caliber .30 M1, has the same profile as the standard ball cartridge, and all components of the two types are identical except the bullets. The tracer bullet weighs $154^1/_2$ grains and consists of four parts, the jacket or outer casing of gilding metal, the tip or slug of hardened lead, the cup or container for the tracing mixture, made of gilding metal, and the chemical mixture which burns until the bullet has traveled about 1100 yd. The propelling charge of the cartridge is so adjusted that the fired bullets will group with the service ball bullets at a distance of approximately 600 yd from the muzzle of the weapon.

Tracer ammunition possesses excellent incendiary qualities, and is therefore very effective against inflammable-gas-filled balloons. It is also occasionally used in rifles for the purpose of target designation.

The caliber .50 tracer cartridge, officially designated "Cartridge, Tracer, Caliber .50, M1," is a counterpart of the caliber .30 M1 tracer cartridge, with the exception that the tracer-mixture container is omitted. The assembled bullet weighs $674^1/_2$ grains, the jacket and slug 405 and $206^1/_2$ grains, respectively, and the tracer mixture approximately 70 grains. This bullet is capable of producing a bright red trace until it has traveled approximately 1700 yd.

In regard to the causes underlying the improvements in accuracy which have been described, it may be interesting to note that accuracy appears to be a function of uniformity, and emphasis on this one thing may be stretched almost to infinity.

Of course, it is apparent that uniformity is desirable in the metal parts of the cartridge, including the primer and case, else there will be differences in the way the round lies in the chamber of the gun. It is equally important that the bullet shall be regular in contour and be seated in the cartridge case so that the length of each complete round shall be the same. Moreover, the dimensions of the rifle barrel must be uniform, and particularly must there be a good "fit" between the bullet before being fired and the beginning of the bore or "bullet seat" in which it rests.

The weight of the primer pellet and powder charge should not vary, because these are the source of the power that speeds the bullet on its way, and variations of either will produce changes in velocity which will result in the shots going high or low.

Not only do variations in the powder charge and primer pellet produce irregularities, but other causes, such as actual variation in the "texture" of the bullet jacket, produce changes in velocity. The temperature of the air, its density, moisture content, and velocity, are also effective to the same end. Thus, even if it were possible to produce perfect guns and ammunition, it would generally not be possible to "shoot through the same hole" every time.

A study of a great number of targets reveals the fact that when the wind is not varying greatly the shots will be distributed above and below what is called the "center of impact" to a greater distance than to the right or left. This is because the inaccuracies due to changes in velocity are added to those produced by other causes. The average vertical dimension of a target will be found to be from 1.3 to 1.5 times the average horizontal dimension under ordinary circumstances where accuracy of the ammunition is being tested in such manner as to eliminate the variation due to wind.

Where extreme care has been used in the manufacture of the powder and primer, and when these have been loaded with the greatest uniformity, it will be found that the average horizontal and vertical dimensions of targets will be approximately equal—this when firings are done in such manner that no deviation of the line of aim takes place, and so rapidly that wind variations from shot to shot are negligible.

Nowadays guns and ammunition are made to conform so exactly to exterior dimensions of the latter that tolerances are very small indeed, and therefore the conclusion has been reached that uniformity of the "interior economy" of the bullet, or rather, lack of it, is the cause of the major portion of remaining inaccuracies.

The behavior of a bullet in flight is found to be so similar to that of a spinning top that the analogy may well be used to illustrate a point. If an attempt be made to spin a top in which there is a weight placed at some point on the periphery, it will be found that the result is a very erratic spin, to say the least, and it will be extremely difficult to make the top "go to sleep." Now, if a bullet be so made that it is like the weighted top, though of course in less degree, it will not fly true, and variations in the distribution of mass with respect to the axis of rotation will produce changes in flight.

An interesting commentary on this study of the causes of accuracy may be made in connection with the results of the competitive trials of ammunition for the national matches in 1921. Upon completion of the tests, it was found that ammunition submitted by the Remington Arms Company for special matches showed the greatest accuracy and remarkable uniformity with targets at 1000 yd, which averaged slightly over 4 in. in mean radius when fired in the Mann rest. The combined averages of the mean radii of the targets fired at 1000 yd, in both the Mann rest and with rifles in the machine rest, was 6.04 in. However, this combined figure is not truly representative of the accuracy of ammunition as is the figure for the Mann-rest firings only. The measurements of the Mann rest targets showed the least variation in mean radius of any similar series.

The accuracy of the ammunition was judged to be due to the extremely uniform bullets, and the uniformity of the bullets, in turn, was considered to be due to the characteristics of the cupro-nickel of which the bullet jackets were composed. In subsequent firings of bullets with cupro-nickel jackets, the accuracy was always superlatively good. If the ammunition for special matches, made up of M1 types, such as the 1925 and 1930, had contained bullets provided with jackets of this particular lot of cupro-nickel or of other materials of equal characteristics, perhaps very remarkable results might have been obtained.

The Basic Laws and Data of HEAT TRANSMISSION[1]

By W. J. KING[2]

V—RADIATION

Nature of Radiant Energy

FOR the present purpose, radiant energy may be regarded as a form of wave motion in the ether, which is propagated over a wide range of wave lengths and is manifested in various forms, such as radio waves, heat, light, and X-rays, in different wave-length intervals. In the range between about 0.4 and 0.7 micron (a micron is a thousandth of a millimeter) radiant energy may be manifested as either light or heat. The adjacent shorter waves are called ultra-violet rays, and the longer waves up to about 300 microns are the infra-red or invisible heat waves.

Fig. 1 shows how the energy radiated from a body at various temperatures might be distributed over wave-length ranges. The curves are drawn in such a way that the energy emitted, per unit of area and time, in any interval, $d\lambda$, is represented by the area under that section of the curve. Thus at a temperature of 1300 C abs or 1300 K (degrees Kelvin) the energy radiated in the interval between 2.9 and 3.1 microns would be $0.2 \times 4 = 0.8$ watt per sq cm. Formulas will be given later for calculating the partial or total energy for any such curve.

Radiant heat and light have much in common, since the same radiant energy may appear as light or heat or both. Even in the longer waves, radiant heat may be refracted, polarized, reflected, transmitted, or absorbed. It is reconverted into ordinary sensible heat only when it is absorbed.

Radiation may therefore be distributed in three ways: (1) in a band or bands of wave lengths; (2) in space [emitted from a surface in certain directions more than in others]; or (3) in one or more planes of vibration [polarized]. Polarization is usually not considered in engineering applications, although in special cases its effect may be significant.[3]

Fundamental Laws and Definitions

A body that absorbs all of the radiant energy falling upon it is called a "black" body. Such a body also radiates energy at the maximum rate possible by virtue of its temperature. It is important to note that the term "black" body was borrowed from optical science to indicate a complete absorber or a full radiator, and that relative optical blackness or color may be no indication of relative thermal "blackness" in the present sense, particularly for low-temperature, long-wave-length radiation.

The ***total emissive power***, E, of a body is defined as the total radiant energy emitted per unit time per unit area of surface of the radiating body.

If the radiant energy emitted per unit of time and area in the range $\lambda \pm {}^1/_2 d\lambda$ is $E_\lambda d\lambda$, then E_λ is the *monochromatic emissive power* of the body at the wave length λ.

Referring to Fig. 1, for a black body, E_λ for any wave length and temperature is given by the ordinate, and E for any temperature is given by the area under the curve, extended to $\lambda = \infty$, or

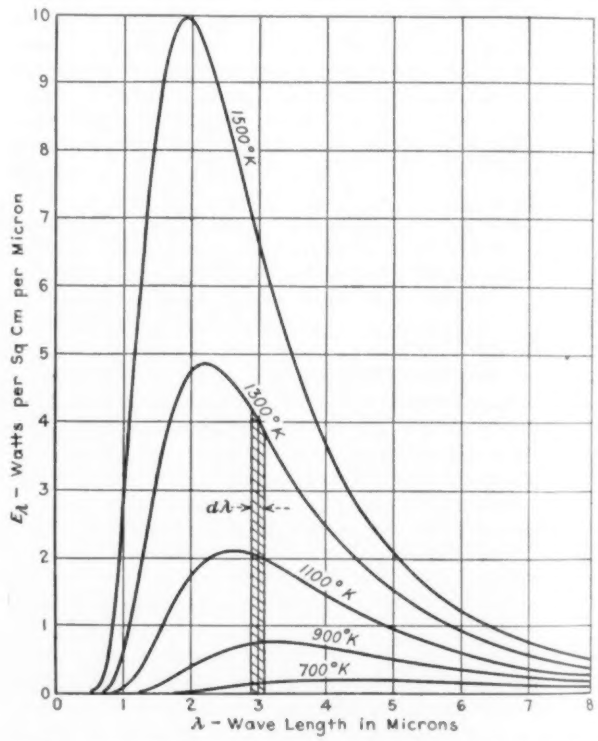


FIG. 1 MONOCHROMATIC EMISSIVE POWERS FOR A "BLACK" BODY AT VARIOUS TEMPERATURES

$$E = \int_0^\infty E_\lambda d\lambda \qquad [1]$$

The values of E_λ given in Fig. 1 were calculated from Planck's formula (which has been verified experimentally):

$$E_\lambda = \frac{C_1\lambda^{-5}}{e^{\frac{C_2}{\lambda T}} - 1} \qquad [2]$$

where $C_1 = 3.7 \times 10^{-12}$ watt · cm² and
$C_2 = 14{,}330$ micron · deg K

It may be seen from Fig. 1 that as the temperature is raised the wave length of maximum emission, $\lambda_{max.}$, becomes shorter. This is expressed by Wien's displacement law:

$$\lambda_{max.}T = 2885 \text{ micron} \cdot \text{deg K} \qquad [3]$$

[1] Part I, a general survey of the subject, appeared in the March issue, pp. 190–194; Part II, on Conduction, in the April issue, pp. 275–279, 296; Part III, on Free Convection, in the May issue, pp. 347–353, and Part IV, on Forced Convection, in the June issue, pp. 410–414.

[2] Engineering General Department, General Electric Company, Schenectady, N. Y.

[3] For example, see W. Meissner and B. Voigt, "Metallic Vacuum-Jacketed Flasks for Liquid Hydrogen," *Zeit. für Instrumentenkunde*, vol. 50 (1930), p. 121.

Thus at the temperature of the sun, about 6000 K, $\lambda_{max.} = 0.48$ micron, which is the wave length of blue light; at 1500 K, $\lambda_{max.} = 1.92$, with only a very small part of the energy in the visible range; and at 100 C (373 K) most of the energy is radiated at wave lengths around 8 microns, which is far into the infra-red and has nothing whatever to do with color.

According to the Stefan-Boltzmann law, the total radiation from a "black" body (or the area under any curve of Fig. 1) is proportional to the fourth power of the absolute temperature:

$$E = \sigma T^4 \qquad [4]$$

The latest and most accurate determinations[4] indicate that the value of the constant is very close to

$$\sigma = 5.76 \times 10^{-12} \text{ watt/sq cm} \cdot \text{K}^4 \qquad [5]$$

or in engineering units, if the temperature is in degrees Rankine (deg F + 460):

$$\sigma = 0.174 \times 10^{-8} \text{ Btu/hr·sq ft·R}^4 \qquad [6]$$

Referring now to the spatial distribution of the radiation from a surface, the ***normal intensity***, i, is defined as the energy emitted per unit time per unit area and per unit solid angle, in a direction normal to the surface. Thus the rate of emission through a small solid angle, $d\omega$, normal to a small surface element, dA, is

$$dq = i\,dA\,d\omega \qquad [7]$$

For an ideal "black" body, the intensity in any direction at an angle θ from the normal is equal to the normal intensity, so that the rate of emission is proportional to the projected area, or

$$dq = i\,dA\cos\theta\,d\omega \qquad [8]$$

This is known as Lambert's cosine law. The integration of [8] throughout the hemispherical solid angle above the surface dA gives the rate of emission in all directions, and leads to the relation between total emissive power and intensity:

$$E = \pi i \qquad [9]$$

Referring to Fig. 2, let A_1 and A_2 be two surfaces whose areas are small compared to the length of the line r joining their centers. If n_1 and n_2 are the normals to the surfaces, then the solid angle subtended at A_1 by A_2 is equal to $A_2 \cos\theta_2/r^2$, and if the surfaces obey the cosine law (Equation [8]) the radiation from A_1 to A_2 will be

$$q_{1-2} = i_1 \frac{A_1\cos\theta_1 A_2\cos\theta_2}{r^2} \qquad [10]$$

According to the theory of exchanges, all bodies at any temperatures above absolute zero are continually radiating heat to their surroundings, even though they may at the same time be absorbing more heat than they emit. For practical purposes it is usually the net exchange of radiant energy between a body and its surroundings, or between two surfaces, that is significant. Thus if the two surfaces of Fig. 2 are perfectly "black," each will absorb all of the radiation falling upon it from the other, and the radiation from A_2 to A_1 will be

$$q_{2-1} = i_2 \frac{A_1\cos\theta_1 A_2\cos\theta_2}{r^2} \qquad [11]$$

Substituting the values of i_1 and i_2 from [4] and [9], the net exchange of radiation will be

$$q = q_{1-2} - q_{2-1} = \frac{\sigma}{\pi}\left(T_1^4 - T_2^4\right)\frac{A_1\cos\theta_1 A_2\cos\theta_2}{r^2} \qquad [12]$$

Since most industrial materials depart appreciably, and some very considerably, from the black-body condition, it is generally necessary to include in all radiation formulas some sort of term for the relative "blackness" of actual bodies.

The ***monochromatic emissivity***, ϵ_λ, of a body is defined as the ratio of the monochromatic emissive power of the body to that of a black body at the same temperature and for the same wave length.

The ***total emissivity***, ϵ, is the ratio of the total emissive power to that of a black body at the same temperature.

In general, radiation falling upon a surface is partly absorbed, partly reflected, and, if the body is very thin or transparent (diathermanous), partly transmitted. The ***absorptivity***, a, and ***reflectivity***, R, of a surface are the fractions of the incident radiations respectively absorbed or reflected. Similarly, the ***transmissivity***, D, of a body is the fraction of the radiant energy falling upon the body which is transmitted. In general, $a + R + D = 1$, or, for opaque bodies, $R = 1 - a$.

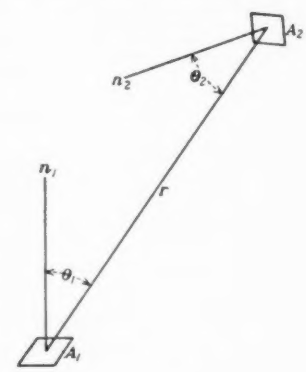


FIG. 2

Kirchhoff's Law, based on theoretical and experimental grounds, states that for radiations of the same wave length and the same temperature, the emissive power divided by the absorptivity is the same for all bodies and is equal to the emissive power of a perfectly black body. This applies to total as well as to monochromatic radiation, and since the emissivity of a black body is unity, it follows that, for any body,

$$\frac{a}{\epsilon} = 1 = \frac{a_\lambda}{\epsilon_\lambda} \qquad [13]$$

In other words, for the same temperature and wave lengths, a good absorber is also a good radiator, but it is important to note that a given surface may have a low absorptivity for high temperature or solar radiation, and yet have a high emissivity at low temperature (long wave lengths).

If a body radiates energy over a continuous band of wave lengths, so that its spectral distribution curve is similar to the curves of Fig. 1, and its monochromatic emissive power or emissivity at any wave length is a constant fraction of the corresponding black-body value, it is called a "gray" body. Obviously the total emissivity or absorptivity for such a body would be equal to its monochromatic emissivity at any wave length.

Properties of Materials With Respect to Radiation

1 Emission and Absorption

(*a*) *Metals*. Bright metallic surfaces absorb or radiate relatively little heat at any temperature. They usually radiate about as gray bodies,[5] but the angular distribution departs considerably from the cosine law. The maximum emission usually occurs at an angle of about 75 deg from the normal,

[4] F. E. Hoare, *Phil. Mag.*, vol. 13, no. 84, Feb., 1932, p. 380.
C. E. Mendenhall, *Phys. Rev.*, vol. 34 (1929), p. 502.
"Handbuch der Experimental Physik" (Wien-Harms), vol. 9 (1929), part 1, p. 455.

[5] See G. R. Greenslade, *Heat. Piping and Air Cond.*, vol. 3 (1931), p. 50.

and E. Schmidt[6] has found that the average intensity for all directions is about $^4/_3$ times the normal intensity.

H. Schmidt and E. Furthmann[7] have examined several theoretical formulas for the total emissivity of polished metal surfaces, and found that their own experimental values of ϵ, measured in a direction normal to the surfaces of a number of metals at temperatures from about 200 to 600 C, agreed moderately well with Foote's[8] formula:

$$\epsilon = 0.576\sqrt{\rho T} - 0.178\,\rho T \qquad [14]$$

where ρ is the electrical resistivity in ohm-cm and T is the absolute temperature, deg K. According to E. Schmidt's results, the average emissivity for all directions should be about 33 per cent higher. As a matter of fact, unless the surface has a very high polish, the emissivity is apt to be still higher. The effect of oxidation in increasing the emissivity is frequently marked in the case of metals, such as copper and iron, which oxidize readily.

The average total emissivities for a number of metals, based on data collected from various sources,[9] are given in Tables 1 and 2. For metals which are only slightly oxidized, or tarnished, values of ϵ intermediate between those of Table 1 and Table 2 should be used.

The value of ϵ for aluminum or bronze paint is about 0.5.

(*b*) *Non-Metals*. At ordinary temperatures, most non-metallic solids, such as porcelain, glass, paper, cloth, building materials, and enamels and paints *of any color*, have emissivities in the neighborhood of 0.90 to 0.95.

Although very few data are available, the indications are that for most liquids the emissivity is about 0.95. According to E. Schmidt[6] the emissivity of electrical non-conductors should depend upon the refractive index, decreasing almost linearly from $\epsilon = 1.0$ when the index is 1.0 to $\epsilon = 0.5$ when the index is 5.5. Both solids and liquids in this class radiate approximately as "gray" bodies, and do not depart very considerably from the cosine law.

The nearest approach to absolute black-body emission or absorption is realized in the case of radiation passing through a small hole in a hollow enclosure, such as a sphere or box. No matter what the nature of the inner lining may be, the incident radiation is almost completely absorbed after successive reflections within the chamber. Similarly for slotted, finned, or corrugated surfaces of any materials, the value of the effective emissivity approaches unity as the relative depth of the slot increases. For such cases the envelope, rather than the developed area, should be used in computing the radiation.

(*c*) *Flames and Gases*. The subject of radiation and absorption of heat by flames and gases is so complex that only a few salient facts may be mentioned here. Further information and references will be found in a recent paper by Hottel.[10] The emissivity of a flame increases with the depth and luminosity, approaching 0.95 for thick, smoky flames. In a large, water-cooled boiler furnace, or in an ingot-heating furnace,

TABLE 1 AVERAGE TOTAL EMISSIVITIES OF CLEAN, SMOOTH METALLIC SURFACES AT VARIOUS FAHRENHEIT TEMPERATURES

	Values of ϵ		
	70 F	1000 F	3000 F (*a*)
Aluminum	0.05	0.075	..
Brass	0.05	0.06	..
Copper	0.04	0.08	0.15
Iron, cast or wrought	0.20	0.25	0.28
Lead	0.08	...	..
Monel metal	0.07	0.10	..
Nickel	0.06	0.10	..
Platinum	0.036	0.10	0.20
Silver	0.025	0.035	..
Steel	0.20	0.25	0.28
Tin	0.08	...	..
Tungsten	0.03	0.09	0.25
Zinc	0.10	...	..

(*a*) Or molten, if the melting point is below 3000 F.

TABLE 2 APPROXIMATE TOTAL EMISSIVITIES OF OXIDIZED METALS, AT TEMPERATURES BELOW 1500 F

	ϵ
Aluminum	0.10–0.20
Brass	0.25–0.60
Copper	0.55–0.75
Iron and steel	0.60–0.90
Monel metal	0.40–0.50
Nickel	0.40–0.60

about 40 to 60 per cent of the heat is usually transmitted by radiation.[11]

Only trimolecular or heavier gases seem to radiate or absorb heat appreciably. Haslam and Hottel[12] have given curves for the total radiation due to carbon dioxide and water vapor, in terms of the temperature, thickness, and partial pressure. As these authors point out, "At low temperatures or with thin gas layers, heat transfer by gas radiation is negligible. At high temperatures and with thick layers it is the controlling factor."

Haslam and Hottel's curves for water vapor were based on some older absorption data, which they suspected were not very reliable. In a recent paper, E. Schmidt[13] has given the results of some careful measurements, which show considerably higher values. These are reproduced in Fig. 3. The tests were made with steam at atmospheric pressure, but the curves may be used for the emissivity of vapor-air mixtures if the actual thickness, s, is multiplied by p_w/p, the ratio of the partial pressure of the water vapor to the total atmospheric pressure. If the source of the radiation is a solid object at a temperature within a few hundred degrees of that of the gas, the absorptivity of the gas will be about equal to its emissivity. Thus, a layer of air 10 ft thick, at a temperature of 68 F (20 C) and 70 per cent relative humidity, will absorb about 23 per cent of the radiation falling upon it from an ordinary steam radiator. In general, radiation passes through dry air without warming it.

2 TRANSMISSION

In gases, all of the radiation that is not absorbed is transmitted. In transparent liquids and solids, a small percentage may be reflected by the surfaces, the remainder being either transmitted or absorbed. The absorption is usually expressed by means of an exponential function of the form

$$I = I_0 e^{-kL} \qquad [15]$$

[6] E. Schmidt, Beihefte zum *Gesundheits-Ingenieur*, series 1, no. 20. Verlag R. Oldenbourg, Munich, 1927.

[7] H. Schmidt and E. Furthmann, Mitt. Kaiser-Wilhelm-Inst. für Eisenforschung, vol. X, no. 12, Abhandlung 109. Verlag Stahleisen, Düsseldorf, 1928.

[8] P. D. Foote, Bull. U. S. Bur. Stds. no. 243 (1915).

[9] "Int. Crit. Tables," vol. V (1929), p. 237.
"Mech. Engrs.' Handbook" (Marks), 3rd Ed., McGraw-Hill, N. Y., 1930.
"Handbuch der Physik" (Geiger-Scheel), vol. 21 (1929), pp. 190–272.
R. H. Heilman, MECHANICAL ENGINEERING, vol. 51 (1929), p. 355. See also refs. 6 and 7.

[10] H. C. Hottel, MECHANICAL ENGINEERING, vol. 52 (1930), p. 699.

[11] See D. W. Wilson, W. E. Lobo, and H. C. Hottel, *Ind. Eng. Chem.*, vol. 24, May, 1932, p. 486.

[12] R. T. Haslam and H. C. Hottel, Trans. A.S.M.E., vol. 50 (1928), paper FSP-50-8, p. 9.

[13] E. Schmidt, *Forschung*, vol. 3 (1932), no. 2, p. 57.

where L is the length of the path in which the intensity is reduced from I_0 to I. Values of the absorption coefficient k for various substances are given in the International Critical Tables, Vol. V. It may be mentioned here that while transparent substances, such as water or glass, may transmit up to 95 per cent of the light or short-wave heat falling upon them, they are usually very opaque to long-wave, low-temperature radiation.[14] A few substances, notably rock salt and sylvite, transmit radiant heat up to wave lengths of about 20 microns.

Radiation Between Surfaces

For practical applications, Equation [12] must be modified to take into account the multiple reflections and absorptions

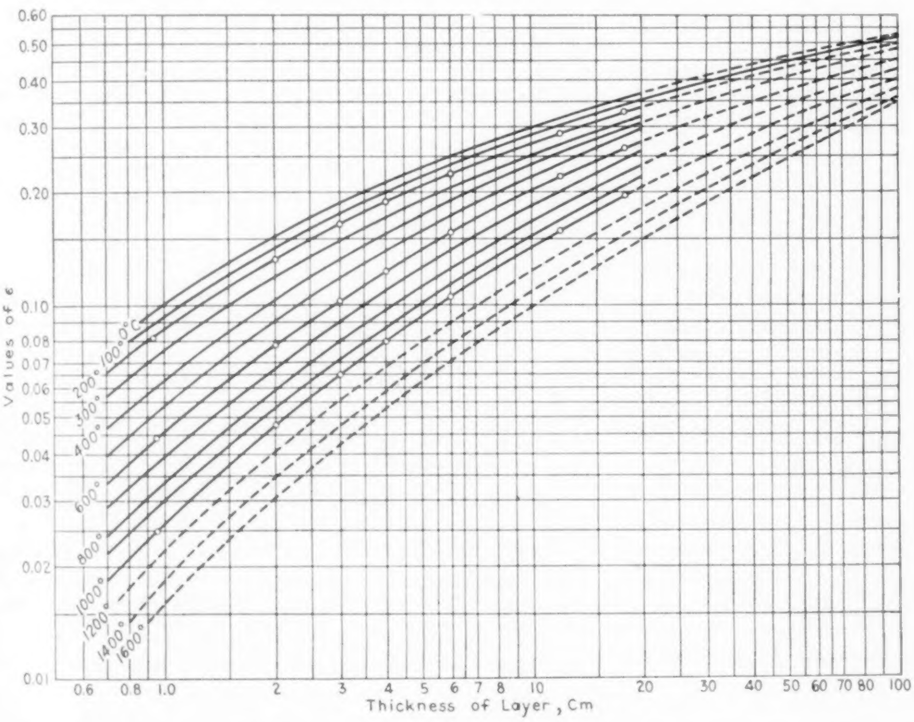


FIG. 3 EMISSIVITY, ϵ, OF WATER VAPOR FOR VARIOUS THICKNESSES AND CENTIGRADE TEMPERATURES
[From E. Schmidt, *Forschung*, vol. 3 (1932), p. 57.]

between non-black surfaces. The method is given by Moore,[15] Saunders,[16] and ten Bosch.[17] For two surfaces which are small relative to their distance apart (Fig. 2), Equation [12] becomes:

$$q = \epsilon_1\epsilon_2 \cdot 0.174 \left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] \frac{A_1 \cos\theta_1 A_2 \cos\theta_2}{\pi r^2} \text{ Btu/hr} \qquad [16]$$

if r is in feet, A_1 and A_2 are in sq ft, and T_1 and T_2 are the corresponding absolute fahrenheit temperatures. This equation may be used, for example, to calculate the direct radiation from a radiant-heating panel whose emissivity is ϵ_1 to a window pane whose emissivity is ϵ_2.

The term $A_1 \cos\theta_1 \cos\theta_2/\pi r^2$ is sometimes called the "configuration factor" or "angle factor" of A_1 on A_2. If A_2 is relatively large, the value of this factor will vary considerably at different points on the surface, so that a mean value, the arithmetical average of the factors computed for several points on A_2, should be used. For convenience, let this average value of the angle factor be represented by $f(A)$, and let

$$f(T) = 0.174 \left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] \qquad [17]$$

Then the net radiation absorbed per square foot at A_2 will be

$$\frac{q}{A_2} = \epsilon_1\epsilon_2 f(T) f(A) \text{ Btu/hr/sq ft} \qquad [18]$$

More precise results, based on the integrated angle factors, for a number of other configurations are given by Hottel,[10,18] and by Barker and Kinoshita.[19]

For a few simple cases the angle factor is unity if the proper emissivity factor is used. For example, for two parallel planes whose areas are large compared to their distance apart, the radiant-heat exchange per square foot of either surface will be

$$\frac{q}{A} = \frac{f(T)}{\dfrac{1}{\epsilon_1} + \dfrac{1}{\epsilon_2} - 1} \text{ Btu/hr/sq ft} \qquad [19]$$

The radiation between such surfaces may be greatly reduced by interposing one or more partitions or screens between the two, particularly if bright metal foil or sheets are used for screens. If n screens are interposed, and all surfaces are of the same material, the radiation will be reduced in the ratio $1/(n+1)$.

For concentric cylinders or spheres, the emissivity factor depends somewhat upon the nature of the surfaces (see ref. 10), but in most cases the radiation will be given, with little error, by the formula:

$$\frac{q}{A_1} = \frac{f(T)}{\dfrac{1}{\epsilon_1} + \dfrac{A_1}{A_2}\left(\dfrac{1}{\epsilon_2} - 1\right)} \text{ Btu/hr/sq ft} \qquad [20]$$

where A_1 is the area of the enclosed body.

In many practical cases the radiating or absorbing body concerned is small relative to its surroundings, as, for example, a steam pipe, or a furnace wall, or a wet-bulb thermometer, in a room. For such cases the radiation formula appears in its more familiar form:

$$\frac{q}{A_1} = 0.174\,\epsilon_1 \left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] \text{ Btu/hr/sq ft} \qquad [21]$$

[14] See R. A. Miller and L. V. Black, *Heat. Piping and Air Cond.*, vol. 4 (1932), Feb., p. 143.
[15] A. D. Moore, "Fundamentals of Electrical Design," McGraw-Hill, N. Y., 1927.
[16] O. A. Saunders, Proc. Phys. Soc., vol. 41 (1929), p. 569.
[17] M. ten Bosch, "Die Wärmeübertragung," J. Springer, Berlin, 1927.
[18] H. C. Hottel, Trans. A.S.M.E., vol. 53 (1931), paper FSP-53-14, p. 265.
[19] A. H. Barker and M. Kinoshita, Univ. of London, Dept. Heat. and Vent. Engng., Bull. No. 1, 1923.

For comparing or combining the radiation component with the convection or conduction components, a radiant-heat-transfer coefficient, h_r, may be derived from Equation [21] by dividing by the temperature difference. Thus, let F_T be the "temperature factor" defined by the expression

$$F_T = \frac{0.174\left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right]}{T_1 - T_2} \text{ Btu/hr/sq ft/F} \ldots [22]$$

The coefficient will then be given by

$$h_r = \epsilon_1 F_T \text{ Btu/hr/sq ft/F} \ldots\ldots\ldots\ldots [23]$$

Values of F_T for ordinary fahrenheit temperatures are given in Fig. 4. To illustrate the use of these curves in connection

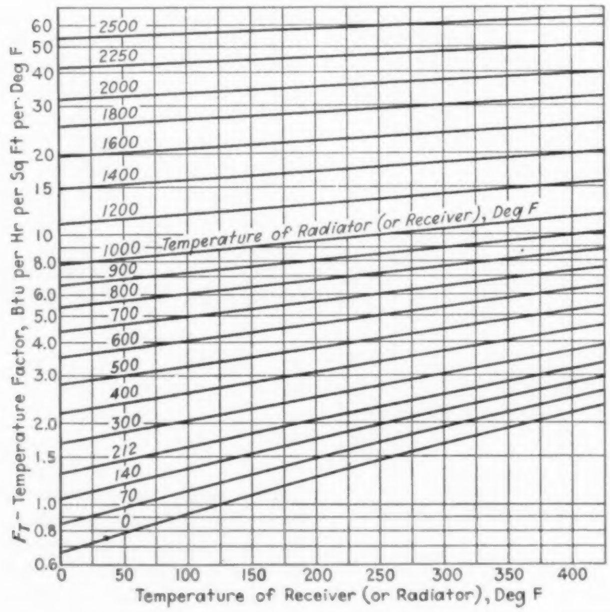


FIG. 4 VALUES OF THE TEMPERATURE FACTOR F_T FOR VARIOUS FAHRENHEIT TEMPERATURES

($F_T = 0.174[(T_1/100)^4 - (T_2/100)^4]/(T_1 - T_2)$, where T = deg F + 460.)

with Equation [23], take for example the radiation from a bare tin hot-air duct at a temperature of 150 F in a room whose walls are at a temperature of 70 F. From Fig. 4, F_T is 1.3. The emissivity of a *clean* tin surface is given in Table 1 as 0.08. Allowing for a moderate amount of tarnish (and herein lies the weakness in many radiation calculations), the value of ϵ_1 will be estimated as about 0.15. The radiation coefficient is then $h_r = 0.15 \times 1.3 = 0.195$ Btu/hr/sq ft/F, or the radiation is $0.195 \times 80 = 15.6$ Btu/hr/sq ft. Assuming an air temperature of 75 F and a pipe diameter of 9 in., the free-convection coefficient would be about 0.73 Btu/hr/sq ft/F, and the convection loss $0.73 \times 75 = 54.7$ Btu/hr/sq ft. Radiation would then represent about 22 per cent of the total heat dissipation. If the pipe is covered with a *thin* sheet of asbestos paper, the temperature drop through the paper may be negligibly small, but the surface emissivity would be very close to 0.95. In this case the radiation would represent 64 per cent of the total loss, and the latter would be more than double the bare-pipe loss.

SOLAR RADIATION

In general, when radiant heat from the sun falls upon the surface of a body, part is reflected and the remainder is dissipated by reradiation, by convection, and by conduction through the body. The general problem of the heat flow through such a body is complicated by the periodic variation in the angle and intensity of the sun's rays. This has been treated in an excellent paper by Houghten [20] and his associates.

Wetherill and Montsinger[21] have reported a study of solar radiation in a paper on the effect of color on the temperature of transformer tanks, which included some emission and absorption data collected by the author some years ago. Since some of the latter were estimated from rather inadequate data, their accuracy is very questionable. In fact, very little has yet been published on the actual absorption of solar radiation by surfaces, but from information gathered from various sources it is possible to make some reasonably accurate estimates.

On a clear day, the average solar radiation at noon upon a surface facing the sun is about $q = 320$ Btu per hr per sq ft. Of this, the amount absorbed will be equal to aq, if a is the absorptivity of the surface. For *solar* radiation the value of a depends primarily upon the color, although it is influenced somewhat by the nature and roughness of the surface. Approximate values of a for a few surfaces are given in Table 3. These were derived mainly from monochromatic reflectivity data taken from the "International Critical Tables," Vol. V, and from a recent paper by Beckett.[22]

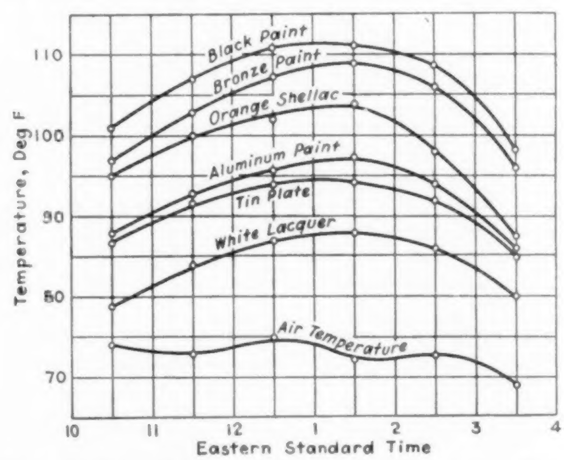


FIG. 5 TEMPERATURES ATTAINED BY VARIOUS SURFACES EXPOSED TO RADIATION FROM THE SUN

TABLE 3 APPROXIMATE ABSORPTIVITY, a, OF VARIOUS SURFACES FOR SOLAR RADIATION

	a
Magnesium carbonate	0.02
Silver, polished	0.07
White paper	0.25
Whitewash	0.25
Aluminum paint	0.35
Nickel, polished	0.40
Steel, polished	0.45
Copper, polished	0.50
Galvanized iron, new	0.65
Red brick or tile	0.65
Slate, gray	0.90
Lampblack	0.97

Fig. 5 gives the results of some tests conducted by the author to determine the temperatures attained by a number of small oil-filled tin cans, embedded in a thick slab of insulite, with

[20] F. C. Houghten, et al., *Heat., Piping, and Air Cond.*, vol. 4, April, 1932, p. 288.

[21] L. Wetherill and V. M. Montsinger, Trans. A.I.E.E., vol. 49, no. 1, Jan., 1930, p. 41.

[22] H. B. Beckett, Proc. Phys. Soc., vol. 43 (1931), p. 227.

one flat surface exposed to the sun. The temperatures were measured by thermometers inserted through cork stoppers into the oil, and represent the net effect of absorption, reradiation, and convection, plus a small loss by conduction through the insulite. It is interesting to note that the temperatures increase progressively with the relative blackness of the color, indicating that the absorptivity was the controlling factor.

Additional information on the general subject of thermal radiation will be found in the following texts:

A. Schack, "Der Industrielle Wärmeübergang," Verlag Stahleisen, Dusseldorf, 1929.

Thos. Preston, "Theory of Heat," 4th Ed., McMillan and Co., London, 1929.

G. Ribaud, "Traité de Pyrométrie Optique," Encyclopédie Photométrique, Cinquième Section, vol. IV (1931).

Ch. Roszak and M. Vernon, "Nouvelles Études sur La Chaleur," Dunod, Paris, 1929.

The Trend of Motor-Car Design

(Continued from page 486)

be supposed, there is more friction with them than with the regular balloon tires. In spite of this we shall no doubt be using air wheels in the near future, or at least something similar to them.

DIESEL-ENGINED CARS

The Diesel engine has come to the front in the last few years, and has of course made wonderful headway in marine and stationary work, as well as in excavating and other machinery running at constant speed.

A few Diesel engines are being used abroad on motor vehicles and seem to be giving good results, and two American manufacturers are making some headway in adapting them to automotive work. The difficulties so far encountered have been those of getting complete combustion under heavy load, flexibility in accelerating at low speeds, also roughness at low speeds and greater weight per horsepower of output. Incomplete combustion, besides having other disadvantages, causes smoke.

While it seems improbable that Diesel engines will be used for passenger cars in the near future, it looks as if there was a possibility that with certain looked-for improvements we shall at least use some of them in heavy-duty trucks. The multi-cylinder gasoline engine is with us to stay, but in Diesel engines it is more difficult to make a small cylinder work properly than a large one, so that multi-cylinder Diesel engines, that is, with more than six cylinders, for motor vehicles will be slow in making their appearance on the automobile horizon.

Power brakes, not only on all motor buses and trucks but on all passenger cars, are coming rapidly.

This article has referred mostly to passenger cars. The trends in motor buses and trucks are even more pronounced, and in some respects revolutionary. While some of those noted here have appeared recently, most of them will not make their appearance before the end of the current year.

Magnetogorsk

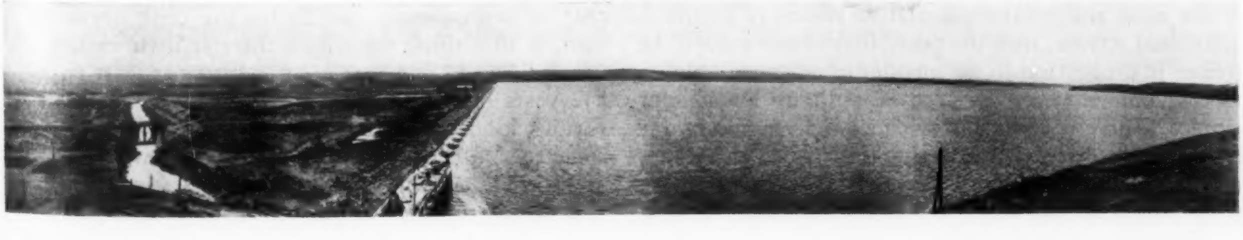
(Continued from page 466)

difficult problem. Magnetogorsk furnace No. 1 has already produced its rated capacity of 1000 tons per day, notwithstanding that more or less intermittent operation has been unavoidable.

The furnace was lighted in midwinter with sub-zero weather prevailing, before certain features of equipment which are considered essential in the United States were completed, and with an operating crew untrained in the handling of such thoroughly modern equipment. These circumstances in America would probably make the starting of a similar plant prohibitively expensive. It is, however, an interesting sidelight on the Russian viewpoint that they considered the early announcement of an important accomplishment as being paramount to ordinary economic considerations. It would be rash, moreover, to conclude that such a stand was not justifiable, when the close relationship of industrial to political affairs in the U.S.S.R. is considered. Under such circumstances the going into action of the first of Russia's new metallurgical giants expressed a materialization of planning and a consummation of intensive effort in construction which had a value that could not be measured in dollars or rubles.

EFFECT OF PROJECT ON RUSSIAN ENGINEERS

Whatever the ultimate success of the Soviet program may be as compared with that of the establishments of the older manufacturing countries, the performance of such tasks as are called for in the building of Magnetogorsk will unquestionably result in developing confidence and self-reliance among the Russian engineers and workers. Industrialism means pioneering to the Russians, and it may bring them returns in character development in the same manner and measure that pioneering on this continent benefited our own people.



MECHANICAL ENGINEERING

Vol. 54 JULY, 1932 No. 7

GEORGE A. STETSON, *Editor*

Accuracy in Gear Teeth

WHETHER gear teeth should be cut accurately is questioned in an editorial in *The Engineer* of April 15, 1932, in connection with a paper on the Performance of Gear Wheels, presented by Messrs. Hyde, Tomlinson, and Allan early in April before the Institution of Automobile Engineers in London.

The question is not, of course, whether gear wheels should be accurate, but when should they be accurate. The simplest thing is to cut them to the geometric shape determined by the gear formula, which is now done to a tolerance of one or two ten-thousandths of an inch. The only trouble is that a tooth, no matter how accurately cut, does not retain its shape under the strains of actual operation.

It would appear, therefore, that gear teeth should be so cut that they will have the desired shape when subjected to the working strains. The problem is a very complex one, involving not only the elastic properties of the material of which the wheels are formed, but the load transmitted and its constancy or variability, together with a number of other factors, such as the inertia of the parts transmitting the motion. The nominal load is not a real measure of the true value of the impact stresses thrown upon the teeth by their very slight departure from perfection, and, for example, Arthur Orcutt in discussing the paper referred to, stated that his company is now grinding gear wheels for aircraft engines with the teeth actually distorted in order that when they are under load they may have the correct form. It should be remembered, however, that the gears of airplane engines do not operate in exactly the same way as those in a motor car where the loads are far less uniform and the possibilities of tooth distortion greater.

Economics Discussion Groups

IF, AS MANY persons assume, the fluctuations of the business cycle are seriously affected by the psychology of the mass and by the cumulative effects of countless individual actions, then the possibility of control will be greater in proportion to the amount of informed opinion on economic subjects that can be built up among our people. There is abundant evidence that engineers, for example, are discussing and thinking about these subjects seriously and constructively. Old theories are being dusted off and submitted to the searching light of comparative inquiry with newer concepts. Attempts at analysis of causes and conditions, at solutions, temporary and permanent, and at a reasonable understanding of complex but interrelated forces engage the attention of men in all walks of life. Last month we published a report on the balancing of economic forces that a group of engineer lay-economists, acting as a committee of the American Engineering Council, prepared. For months our pages have provided a means for bringing the writings of engineers on economic subjects to engineer readers. Thus we have sought to capitalize what seems to be a significant movement.

In our correspondence column this month appears a letter from one of our readers suggesting the formation all over the country of discussion groups for the purpose of building up a considerable body of informed opinion in respect to economic problems. With this suggestion, which is made by one who himself has been a member of such a group, we are in sympathy, and commend it to all engineers. While present interest in these non-technological problems on the part of engineers appears to be a phenomenon of the depression, it is important to maintain such interest in the better days that are coming. Wise conduct during recovery and prosperity is quite as essential as it is during the less agreeable phases of the business cycle.

Fully Preventable Automobile Accidents

ACCORDING to a paper before the Society of Automotive Engineers which is abstracted in the Survey of Engineering Progress on a preceding page of this issue, thousands of automobile accidents are fully preventable by proper attention to engineering features which, if neglected, would actually seem to invite trouble. It would appear obvious that a windshield should be so designed as to afford unrestricted vision both to the right and left, and yet as the author of the paper, Victor W. Killick, points out, many accidents at intersections have occurred because a portion of the driver's left-side view was obstructed by an excessively wide corner post. Not only this, but of late corner posts have been made with the base flared out for artistic effect. A collision at an intersection, however, can hardly be called successful from the artistic point of view.

Low seats which make it impossible for drivers to see children standing or walking in front of their cars, or even to notice the right-hand edge of the road, with the possibility of running over it into a ditch, are also entirely unnecessary. Locating the light switch on top of the steering column in such a way that it is frequently caught by the coat sleeve on a turn, is something for which there is little excuse. It is surprising to find that in an industry at least twenty-five years old, with more then twenty million cars of various kinds running on the roads, we have not yet come to a full realization of such elementary necessities as those of making electric switches stay thrown, and of so arranging the various car members that they will

afford unrestricted vision to the driver. Is this a case of the blind leading the blind—engineers designing cars in which the driver cannot see what is coming ahead, and drivers accepting this situation year after year?

If engineers can obviate at least a portion of these accidents by such simple measures as providing light switches that cannot be thrown off on a turn by the sweep of a coat sleeve, and seats from which drivers can see where they are going, it certainly behooves the former to busy themselves without delay in the production of a reasonably safe car, particularly as this can be done apparently without any added cost or outlay in plant investment.

Saving Time and Money on Publications

SOME time ago we suggested that a reduction in the budgets of Federal Bureaus might not be an unmixed blessing because "pruned trees bear better fruit." Reductions of income have affected practically all individual and organized activities, necessitating a careful scrutiny of the reasons for their justification. As a consequence some have been given up, and others have been modified to suit the conditions of the moment. Not all of these enforced changes have been for the worse. The "sweet uses of adversity" have brightened many an otherwise doleful outlook. Better fruit will be gathered from many a pruned tree.

A case in point about which we are optimistic is that of the technical publication. If reduced resources will make it possible to insist upon brevity, they will have served a good purpose. Technical papers are too frequently unnecessarily long and tiresome, thereby wasting not only good money in the publication of needless words, but the reader's time and patience.

Every one, not excluding editors, contributes to this twofold waste. Almost every one will agree that every one's writing but his own is too verbose. A 25 per cent reduction in volume would save a quarter of the time and money spent on technical literature—but there would be no need to reduce the number and value of the ideas expressed.

Steel, Prince or Pauper

FROM prince to pauper and back again has been the well-known history of the steel industry since its inception. It was with the idea of stabilizing this giant among national industries that the United States Steel Corporation was created. The formation of this corporation was followed by an expansion of the manufacturing facilities in this country which rapidly brought it to the forefront among nations in this respect.

On the whole, during the period between the end of the panic of 1907 and the crash of stocks in 1929, the steel industry prospered in spite of its ups and downs. Today it is not prosperous. The passing of dividends on common stocks and the apparent uncertainty of the continuation of full dividends on certain preferred stocks shows how matters stand.

There are four ways out of this unpleasant situation. The most effective and natural one is, of course, a general revival of business and an increase in the consumption of steel, but this does not lie in the power of the steel companies to effect. There is no question that the industry in this country is over-equipped. On the other hand, however, it is working at less than 25 per cent of capacity, which means that even if it were not over-equipped it would still be working at a rate insuring anything but profits.

The discovery of new markets would provide another way out. This does not necessarily mean foreign markets. The steel industry lives by its domestic trade, and home markets will have to be created in order to bring relief to the industry. From this point of view it is significant that whereas the output of standard products is at a low point, that of comparatively novel specialties is much nearer normal. For example, the companies engaged in manufacturing the modern rustless and stainless steels and the better grades of welded pipe have comparatively little to complain of in regard to business in these lines. The lesson is that one cannot get rich selling, say, brown sugar or housepaint.

Then there is the possibility of ruthlessly eliminating all departments and plants that are not paying their way. Practically all of the big companies of today were formed by mergers with and purchases of other companies. As a result, many companies have departments and mills which were logical parts of the older and smaller organizations before merger or purchase, but which today are trying to do work already done more economically and efficiently by other units. This does not apply in cases where the existence of several mills is justified by the railroad rate structure or proximity to markets. It does apply, however, where mills are operated simply because no one has taken the trouble to figure out whether or not it pays to operate them, or knowing that it does not, has not had the courage to write off several million dollars by scrapping old mills.

The fourth and last method is by way of mergers. In the past, as we know now, not all mergers were carried through because it was really believed that economy in production or more effective distribution would result. There were times in the boom days when a merger meant a jump in the value of securities or special financing, with the incident flow of commissions to the bankers. The magic by which two concerns that are losing money can be joined and thereby start making money is just as inexplicable as the widely held assumption that "two can live cheaper than one." Nevertheless all indications are that the present commercial situation in the steel industry will bring about a wide merger movement. It is always possible that a merger will place a company managed by men who have lost the confidence of their bankers or stockholders under presumably more competent management.

Anything that can pull the steel industry out of its present state of pauperdom would be tremendously important for all the engineering trades as well as for the general welfare of the country.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS (See also Internal-Combustion Engineering: The Guiberson Diesel Engine)

The Kohl Tailless Monoplane

THIS monoplane, designed by Hermann Kohl, has been recently tested at the Tempelhof Aerodrome at Berlin, and is said to have shown a surprising performance. Unlike certain other tailless airplanes (Dünne, Pterodactyl, etc.) which are all built with the wings forming a V, the Kohl machine has wings forming an isosceles triangle with the leading edge as the base. The spread of the wings is 13 m (42.6 ft) and the maximum depth about 3.50 m (11.5 ft). The lifting area is 25 sq m (269 sq ft) and the total weight 320 kg (704 lb) with a useful load of 200 kg (440 lb). The plane as flown has been equipped with an old Cherub Bristol 30-hp motor. The maximum velocity is said to be 155 km (96.3 miles) per hr, with a cruising velocity of 140 km (87 miles) and a ceiling of 4700 m (15,400 ft). It is not quite clear, however, whether these figures are theoretical estimates or actual performances. There is no question, however, that the plane has been flown. In fact, it is stated that the apparatus has flown with a load of 20 kg per sq m (4.1 lb per sq ft) and 17 kg (37.4 lb) per hp. The original article considers in detail the advantages of such a plane, particularly from a military point of view. It is notable from the photographs in the original article that the Kohl machine has a very short fuselage barely extending beyond the wing. (*Rivista Aeronautica*, vol. 8, no. 1, Jan., 1931, pp. 27–34, 4 figs., *d*)

Flight Tests on an Airplane With a Control Column Giving Warning of Dangerous Wing Loads

SINCE the speed capacity of modern airplanes continually rises, while the reaction time of the human body remains unchanged, it becomes necessary to consider the maneuver stresses likely to arise in the future on account of this increasing disproportion. The highest stress that can arise during any maneuver carried out without loss of height is measured by the ratio of the square of the top horizontal speed to the square of the stalling speed, being indeed given in the usual "accelerometer reading" by this very ratio; hence the load coming on to the wing of an aerobatic machine (constructed to present-day load factors) during such maneuvers will not produce dangerous loads on the wing. It is only when height is lost, so that the speed may rise much above top horizontal speed, that mishandling of the controls by the pilot may lead to structural failure.

In view, therefore, of the increase in speed of modern aircraft, it became necessary to consider the possible introduction of a device to give warning to the pilot when the load on the wings grew dangerously high. A special form of control column containing an accelerometer device was made for this purpose and tried in the air.

The device was tested in the laboratory at R. A. E. to determine the speed of conveyance of the signal in relation to the reaction time of the human body, and subsequently in the air when fitted to the Siskin airplane. It was found that the signal was rapidly given and was easily noticed. (H. E. Wimperis, Scientific Research Department, in Air Ministry of Great Britain Reports and Memoranda No. 1146, July, 1931, 6 pp. and 4 diagrams, *e*)

APPLIED MECHANICS

Efficiency of Energy Transmission at Resonance

SOME engineers believe that energy can be saved by transmission at resonance, and there are now a number of machines that are operating under these conditions. The majority of these belong to the class comprising measuring or indicating apparatus, but there are also mechanical toys, sieves, etc., that utilize resonance phenomena in their operation. In 1913 H. Schieferstein obtained a German patent for a driving device for aircraft operating at resonance. The original article considers the application of undamped and damped oscillating systems, and comes to the conclusion that fundamentally operation at resonance does not result in any saving in the transmission of energy, and that it is justified only where considerations other than saving of energy are of determining importance. This applies particularly to the use of resonance in testing machines. (O. Föppl of the Wöhler Institut, Braunschweig, in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 76, no. 20, May 14, 1932, pp. 483–484, 7 figs., *tA*)

ELECTRICAL ENGINEERING

A Slow-Motion Motor

RESEARCH engineers of the Westinghouse Electric and Manufacturing Company have developed a timing motor that will revolve only twice a day, though by following the same principles the speed could be slowed down to one revolution or less per year.

While the idea is still in the experimental stage and is not commercially available, the fact that it is practical and workable has been demonstrated in a clock of unique design. One feature of this clock is that it has only four moving parts, each of which is necessary to operate one of the hands. The fastest of these revolves only 60 times a minute. If the four points of wear were to be sealed in oil cups and jewels used for bearings as in good watches, the clock should run indefinitely without attention; of course such performance would require that the electric current never be interrupted.

The motor comprises a stator having 118 iron teeth around its inside edge, wound so as to provide a revolving magnetic field. Inside this ring is the rotor, around the outer edge of which are 120 iron teeth. With different numbers of teeth on the two parts only two teeth are synchronized at any one time, and there is a vernier effect around the rest of the circle. This causes the motor to move only the distance of two teeth for each revolution of the magnetic field of the stator. Thus on a 60-cycle system with the stator field revolving at the rate of

3600 times per minute the rotor revolves only 60 times per minute, the speed required for a split-second hand.

Around the inner edge of the rotor ring are 122 teeth; inside this is a second rotating iron ring of still smaller diameter with 120 teeth around its outer edge. In this second reduction of speed the first rotor becomes the stator for the second, but while the first is running forward 60 revolutions, the second is running only one, so that its net progress forward is 1 rpm. This is the speed desired for the second hand.

Attached to the second-hand rotor is a permanent horseshoe magnet which creates a new rotating field in 118 iron teeth driving still another ring with 120 teeth at the rate of 1 rpm. This runs the minute hand. Attached to the minute-hand rotor is a second permanent magnet creating a rotating field in 22 teeth and driving a 24-tooth rotor one revolution every 12 hr for the hour hand. The entire operation may be explained by saying that each rotor travels only two teeth for each revolution of its magnetic field. Obviously by changing the number of teeth, any desired speed may be obtained. (*Electrical Engineering*, vol. 51, no. 5, May, 1932, pp. 319–320, 2 figs., *d*)

ENGINEERING MATERIALS

Inherent Characteristics of Steel

STEEL quality is said to be an elusive property which is not manifested clearly by results of conventional physical and chemical tests. Each individual piece of steel has its own characteristic response to such factors as heat treatment, cold working, or natural aging. Moreover it is not that steel as a whole responds to these conditions, but that each particular piece reacts to the extent of its own capacity, which may be quite different from the capacity of the neighboring piece. The author therefore introduces a term, sensitivity, which means in the case of a piece of steel the latter's characteristic degree of reaction to thermal treatment, cold work, natural aging, and similar factors. Sensitivity varies with the metallic alloying elements, but is supposed to be largely a function of the carbon-steel base.

The dominant factor in determining the characteristics of steel is said to be pig iron. Gradually more and more evidence comes to light that there are obscure phases of iron quality clinging tenaciously to the metal through the steel-making operations and existing to a greater or lesser degree in the finished steel.

Practical examples of steel sensitivity include varying rate of response to annealing, embrittlement of structural sections, breakage in reverse bends, hardening in punching, breakage in shearing, embrittlement in punching, and many others which often are revealed after heat treatment, welding, galvanizing, etc.

It is taken for granted that the steelmaker must accept responsibility in that he has not yet achieved control of sensitivity and is therefore unable to say that one heat of steel after the other will react to cold work in the same degree. On the other hand, the purchaser or fabricator is expected to be governed by the actualities of the situation, to write his specifications in accord with technical facts, and to conduct his operations in full cognizance that the sensitivity effects are present.

However, in presenting this conception of sensitivity it is earnestly desired to avoid giving the idea that sensitivity is an always undesirable characteristic, an incorrect and misleading view. So far as sensitivity is concerned, it is certain that sensitive steel is in certain applications much more useful and desirable than insensitive steel. (Paper before a meeting of the Iron and Steel Institute, New York, May, 1932, by H. W. Graham, General Metallurgist, Jones & Laughlin Steel Corp., Pittsburgh, Pa.; abstracted through *Steel*, vol. 90, no. 21, May 23, 1932, pp. 28–29, *g*)

[In the book, "Principles of Metallurgy of Ferrous Metals," published by The American Society of Mechanical Engineers, it is stated on page 1 that "a piece of steel in many respects resembles one who examines it. Like him it has properties which are determined by the materials of which it is composed, by the treatment it has received—its life history, by forces that act invisibly within it, and finally, by its environment."

"In the first place, therefore, the character of a steel, or in fact, of all iron alloys, is determined by the materials that go into its making. It is also affected by the way in which the steel is made. The method of melting and, in particular, the ability to control the various steps in the process, and hence the final product, is one of the factors the importance of which has not been fully realized."]

FUELS AND FIRING (See also Power-Plant Engineering: Motion of Gases in the Smokestack)

Dust and Sulphur From Powdered-Coal Firing

THE following is an abstract of part of a paper entitled "Pulverized Fuel Firing With Special Reference to Power-Station Practice."

Under the "nuisance clause" incorporated in the British Electric Power Act, electric central stations must take all reasonable precautions to eliminate nuisances, such as smoke, fumes, etc.

The electrical precipitator is perhaps the most effective solution, but its initial expense is high. There are considerable troubles in operation.

Numerically, in England, gas-washing plants seem to be more popular, and there are many variations in the design of this apparatus. At some stations the simple expedient of reducing the gas velocity is employed. The dust precipitation in this method may only amount to about 15 per cent or 20 per cent of the total dust entering the stack. In the tangential system of firing the heavier ash particles are thrown to the sides of the chamber, due to their greater momentum, and fall to the furnace floor. The particles of lighter density are carried to the stack, to be later dealt with by the ash-collecting plant. As the center of the furnace is at a very high temperature, fusion and coalescence of a portion of the total number of particles may occur, and these heavier bodies are projected to the chamber walls, on their way to which they may solidify. In this manner the firing conditions aid collection of dust in the furnace itself, and the demand on the dust-collection plant is relieved. It has been found that from 50 to 60 per cent of the total ash may be collected in the furnace as a result of the use of this system.

As regards the corrosion of metals by sulphur, reference is made to tests conducted in America. Data are given, however, for determining the efficiency of precipitators generally, and on sulphur removal in particular. It has been found that water washing methods lend themselves most readily to the removal of sulphurous matter in the gases. From tests made at the University of Illinois, and by the London Power Company and the British Government chemist, it is said that the final design of plant for a particular installation takes the form of a two-pass vertical concrete tower with banks of catalytic iron scrubbers in the first or down-pass, and wooden scrubbers in the uptake in which the alkaline wash is used. This is

followed by a section for the removal of free moisture from the gases. On the experimental plant the operating cost for power and alkali was 3 pence per ton of coal burned.

In connection with the effect of emission from central power stations on historic buildings, vegetation, and human life, it is stated that while they can be taken care of, the public should realize that any such devices increase the cost of electric energy, and must ultimately be paid for by the consumer.

The paper contains an interesting passage dealing with the movement on foot to supply pulverized fuel direct from the collieries to the user, in which the advantages and disadvantages are briefly stated. It would appear that the only method of transportation of powdered coal contemplated here is by car and not by pipe. (Paper before the *Institute of Marine Engineers, Great Britain*, by S. B. Jackson, read March 8, 1932; abstracted from proof copy, 40 pp., 22 figs., *dp*)

INTERNAL-COMBUSTION ENGINEERING

The Guiberson Diesel Engine

THIS is a radial air-cooled heavy-oil engine operating on the Diesel principle with compression ignition, incorporating a variable-stroke fuel pump and a decompression device which raises the valves completely for idling purposes.

As regards the variable-fuel-control system, by means of one control the stroke of the pump is varied as the time of the injection is advanced or retarded. The duration of the injection is changed in proportion to the amount of fuel injected and the time of injection by moving the control to the extreme position below idling. Some of the details are given in the original article.

The decompression ring, controlled by a single control plate, rides between the fuel and valve cam, having nine small lobes, one per cylinder, that engage each valve-cam follower lifter, lifting all the valves open at the same time. The stroke, timing, and variation are described and illustrated in the original article. A Waco plane powered with a Guiberson Diesel flew from Dallas to Detroit and back in April, 1931. Recently the same ship with the same motor carrying 300 lb excess weight was flown to a height of 21,686 ft, but had to descend as the flier did not carry enough oxygen. (*Aviation Engineering*, vol. 6, no. 4, April, 1932, pp. 19–21, *d*)

LUBRICATION

Lubricants and Their Relation to Engine Tests

ACCORDING to the author, the chemist reads into his particular laboratory tests an engine interpretation which does not exist. Even today if many people are asked what effect the flash point has on the carbonization of oil in an internal-combustion engine, they will say that obviously the higher the flash point, the less the amount of carbon deposited in the engine. As a matter of fact it is often the other way round. In the majority of cases, the lower the flash point, the less the amount of carbon within certain limits which will be deposited in an internal-combustion engine. The specific gravity gives no indication of the value of an oil as a lubricant, and even in turbine lubrication is no longer used as a criterion of lubricating value. In steam-cylinder lubrication it can be omitted as an indication of the lubricating value of an oil, but is included in the specification solely to show the origin of the cylinder oil.

As regards viscosity, the object of a lubricant is to replace solid friction by fluid friction, and the correct lubricant to use is the lowest-viscosity oil which will maintain a film under arduous conditions and at the same time provide a sufficient factor of safety.

For ordinary bearing and axle lubrication the right way to frame a viscosity specification is to get the engineer to ascertain the correct-viscosity oil which will give him a film at his highest running temperature. He should then specify the highest setting point permissible in the circumstances. Viscosities between the highest running temperature and the setting point are unnecessary, and the author gives axle running tests in support of this contention. The viscosity curve is somewhat related to the question of carbonization in internal-combustion engines, and engine tests are given showing this. The more filtered residual oil put in an oil, the flatter will be the curve and the higher the carbonization.

The question of compounding has been fully dealt with by Marshall and Barton from the point of view of piston friction and bearing wear. In some cases compounding is invaluable. Fatty oils exert a decided solvent action upon products of bad combustion and on tars. Steam-cylinder-oil compounding is often of the greatest possible value. A steam-cylinder oil is fed, by injection, into the steam before the steam passes into the valve chest, and is then led into the engine. If the oil atomizes thoroughly in the steam, and is deposited as an even coating over the valves and the cylinders, then satisfactory lubrication will result, but if the oil is taken in in "blobs," there will be uneven lubrication and "shuddering." The author has yet to learn of a case where valves were "chattering" and cylinders "groaning" that could not be remedied by the addition of fatty oil to the cylinder oil, provided the mechanical conditions were satisfactory and the cylinder oil was of good quality. The solvent action of the fatty matter on the hard asphalt present in dark cylinder oils improves the atomizability of the lubricant. It is now generally accepted that the suitability of steam-cylinder oil as a lubricant for all purposes is largely governed by what is termed "atomizability," but there is no laboratory test for measuring that factor. (F. J. Slee, Technical Dept. of Shell-Mex and British Petroleum, Ltd., in a lecture before the Manchester Section of the Society of Chemical Industry, Apr., 1932, abstracted through *Chemical Age*, vol. 26, no. 668, Apr. 16, 1932, p. 342, *p*)

A Possible Criterion for Bearing-Temperature Stresses

THE paper deals with plain journal bearings of the high-speed type and suggests a criterion for the tendency of overheating of these bearings operating at values of ZN/P well up in the fluid-film range. The author believes that the *pv* product or "rubbing factor" does not actually apply to the case of bearings lubricated only by a fluid film. Although it has the dimensions of a rate of heat liberation, it operates under conditions such that the resistance against which motion must be produced is that of fluid viscosity, and is affected only to a slight degree by the load on the bearing. In the expression ZN/P, Z is the viscosity of the oil in centipoises, N the revolutions per minute, and P the bearing load.

According to the author, the heat generated in the fluid film can be dissipated by a combination of conduction, convection, and radiation to the crankcase and oil sump, convection forming the principal mode of transfer. From experience in the laboratory it would be expected that the overall coefficient of heat transfer for the conditions prevailing around a crankpin bearing would increase in proportion to the 0.3 power of the temperature difference. The main bearing should approach more closely the fourth-root law, but it is doubtful if the possible

precision attainable in any heat-flow measurements can justify such small definitions. A formula for the relation between the bearing surface temperature and the effective crankcase temperature is given.

From this work the author recommends the use of $\mu_{210} \times V^2$ where μ_{210} is the oil viscosity in stokes and V the rubbing speed, as a criterion for temperature rises in high-speed plain bearings. A survey of data on cars of 1931 models indicates an average value of $\mu_{210}V^2$ of 6.6×10^5 at maximum engine speeds and with the heaviest oils likely to be employed, the extremes noted being 1.3×10^5 and 13.8×10^5. The discussion, which cannot be abstracted here for lack of space, covered among other things the effect of counterweighted crankshafts, and a brief reference to a bearing-testing machine devised in the General Motors Research Laboratories to test full-sized bearings under actual conditions.

O. C. Bridgeman told about the general equation of power dissipated in a bearing, developed from the work of McKee at the Bureau of Standards. From this it is possible to determine the relative importance of pv as compared with ZN/P as a criterion for bearings.

H. C. Dickinson analyzed the temperature rise in the oil film and came to the following conclusion: Calculating the temperature rise in the center of the oil film, which is its hottest point, from the heat generated and the thermal conductivity of the oil, both of which are sufficiently well known, it is found that this temperature rise for a given rate of heat generation is proportional to the square of the film thickness. Thus it follows that the rise of temperature at the center of the oil film depends only on the rubbing speed and the oil viscosity, not on the clearance or the eccentricity of the journal in the bearing. Hence it is possible to calculate what the maximum rise of temperature in the oil film is for any given speed and journal diameter. The figures are somewhat as follows: For a 3-in. shaft running at 3000 rpm with a normal grade of oil, the center of the oil film will be about 2 F warmer than the metal; for a 6-in. shaft running at 3000 rpm, or a 3-in. shaft running at 6000 rpm, the rise will be 8 F, which is not of much importance even in this extreme case.

This indicates immediately that the oil cannot be used to carry away much of the heat generated in it by friction. Nearly all of this heat goes directly to the metal, and much of it is carried away by the oil which splashes around in the crankcase. If we can supply cool oil to the bearings and take it away hot, this removes heat from the metal; but it would be just about as effective and sometimes safer to circulate the cooling oil through the crankshaft or through some sort of cooling passages as to pump it through the narrow and uncertain clearances of the bearings. (D. P. Barnard, Research Engr., Standard Oil Co. of Indiana, Whiting, Ind., in *S.A E. Journal*, vol. 30, no. 5, May, 1932, pp. 192–197, 7 figs., *eg*)

MACHINE PARTS

Thrustors

THE thrustor is a comparatively new control device. It consists of three main elements: a cylinder containing oil, a piston, and a small motor driving an impeller immersed in the oil. When the motor is energized the impeller creates pressure in the oil, causing the piston to rise as the oil passes from above the piston to the chamber beneath.

Thrustors are made in sizes ranging from those capable of delivering a thrust as low as 50 lb at 2 in. stroke to large sizes rated at several thousand pounds and at a much longer stroke. As the motive power for the ordinary sizes (600 lb or less) is obtained from a fractional-horsepower motor, the cost of power for operation is low.

The time required for a standard thrustor to deliver its full stroke varies from a fraction of a second to several seconds, depending on the load and on the size of the thrustor. Similarly, the return stroke varies with the amount of restoring force.

One of the principal advantages claimed for the thrustor is its smooth operation. Thrustors have been applied already in many fields, such as steel mills, wire-manufacturing plants, riveting machines, printing machinery, etc. The present article describes and illustrates several such applications. One of these is that of stacking the sheets which come from the presses in punch-press practice. The sheets, as they emerge from the press, are fed on to a stacking machine where they come in contact with a limit switch which energizes the thrustor. This device in its upward movement swings an arm around. This arm catches a sheet and pulls it out to the end of the rack where a latch trips and the sheet is dropped on to the pile. One man can care for five of these machines.

An example of the way in which a thrustor may be utilized to meet a special condition is the employment of the device on a spot welder. Here it has been found possible to limit the pressure exerted on the weld to the correct value, so that the quality of the weld obtained is materially improved. This is accomplished by utilizing the varying pressure in the oil chamber of the thrustor, while the motor is coming up to speed, to operate a pressure switch so that, when the pressure in the tank has been built up to a point corresponding to the desired thrust on the welding head, the device is automatically energized. The muscular effort required is also greatly reduced.

This device has also been applied to a machine for stamping coils. Its application in this instance increased production from 300 to 1200 units per hour and eliminated all muscular effort. (R. F. Emerson and S. A. Holme, Industrial Engineering Dept., General Electric Co., in *General Electric Review*, vol. 35, no. 5, May, 1932, pp. 267–270, 15 figs., *d*)

MARINE ENGINEERING

Conversion of the British S.S. "Cadillac" to Superheating

THE economy resulting from the conversion of existing vessels using saturated steam to superheated steam is generally recognized by ship owners, but the time that the ship has to be laid up while the conversion is being made has hitherto militated against the change. This has been done, however, in the case of the S.S. *Cadillac*, a vessel of 17,000 tons deadweight. She is fitted with a quadruple-expansion engine with cylinders $28^1/_2$ in., 41 in., 58 in., and 84 in. in diameter, the stroke being 54 in. Approximately 3700 ihp are developed in ordinary service conditions. The boiler pressure is 220 lb, the steam being supplied by four single-ended boilers 16 ft 3 in. in diameter by 12 ft long. The new superheaters fitted were of the smoke-tube type, designed to give 150 F superheat at the main engine regulating valve. Apart from fitting the superheaters, new cylinder and valve liners were supplied and fitted in the high-pressure cylinder and in the first intermediate-pressure cylinder, and the piston and valve rods were ground and fitted with new packing. In addition to the work mentioned, the boilers were completely relagged, the cylinders were relagged on the sides, the bottoms of the cylinders were lagged for the first time, and new planished-steel boxes were supplied and fitted to go over the top of the cylinder covers with new mattresses on the covers, all this being entirely new work.

With the materials and parts as far as possible prepared in advance, the work has been done in twelve days. It is estimated that the cost of the installation will be entirely offset by the resulting economy in approximately two years. (*Engineering*, vol. 83, no. 3452, Mar. 11, 1932, pp. 311–312, *p*)

A Combination Turbine-Reciprocator Steam Power Plant

W. A. WHITE, a Tyneside marine engineer, has taken out a British patent on a machine in which he proposes to use a fast-running, totally enclosed reciprocator in conjunction with a low-pressure geared turbine, the piston engine also being geared to the one shaft. Mr. White also recently delivered a paper before the Newcastle and District Branch of the Society of Consulting Engineers and Ship Surveyors. In this he compared his own layout with the conventional layout for a steamer having a load displacement of 11,370 tons and a deadweight capacity of 8650 tons

The normal machinery installation would consist of a triple-expansion engine having 24-, 40-, and 60-in. cylinders and 48-in. stroke. The service speed is given in the paper as $9^1/_2$ knots, this being maintained on 1460 ihp at 57 rpm; the all-purposes coal consumption was estimated at 25 tons per day. Substituting a White poppet-valve, totally enclosed triple-expansion engine and a White exhaust-steam turbine, the sizes of the engine cylinders would be reduced to $14^1/_4$ in., 20 in., and 27 in. by 14 in. stroke. The normal revolution speed for the White engine would be 280 rpm, and the weight approximately 12 tons. The engine would exhaust with a 50 per cent cut-off at an absolute pressure of about 6 lb per sq in. into a low-pressure turbine running at 2500 rpm. The propeller revolutions, as with the normal machinery, would be about 57 per min. At 1460 ihp for $9^1/_2$ knots loaded speed, the all-purposes fuel consumption, assuming a boiler efficiency of 72 per cent, would be 0.972 lb of coal per ihp-hr, according to Mr. White's computations. The daily coal consumption is cited as $15^1/_4$ tons.

In the White layout superheated steam is to be used, but the steam temperature is not stated. A considerable superheat would be required in order to maintain the results referred to. (*The Marine Engineer and Motorship Builder*, vol. 55, no. 655, Apr., 1932, pp. 122–123, *dc*)

MEASURING APPARATUS

The Pachimeter

THIS is a machine for measuring the shearing strength of plastic bodies, primarily developed for measuring plasticity of clays, but adaptable to other purposes. The shearing strength in this case is measured in preference to plasticity proper, because it is more fundamental, simpler to measure, and is determined independently of the physical and elastic properties of the material. The principle of the method is as follows:

A mixture of clay and water at the rate of optimum plasticity is made into a cylinder of known radius and length. This is placed between two plates, the upper of which is fixed at the end of a long horizontal beam and pivoted at the other end, thus allowing the plate free vertical movement. The lower plate is moved to and fro through a sufficient amplitude to cause the test cylinder to turn through at least one complete revolution. It is found that no permanent lengthening (and simultaneous thinning) occurs unless the upper plate is exerting more than a certain critical stress on the test cylinder. The machine is designed to measure this stress.

Certain materials tend to deform elastically under very small stresses, though the original shape is recovered as soon as the stresses are removed. Such materials would give misleading results in the pachimeter, if no precaution were taken to eliminate this elastic effect. The original article tells how it is done.

Fig. 2 of the original article shows a photograph of the machine. It is rather interesting to note that the entire device is apparently built from parts of a construction toy. (R. K. Schofield and G. W. Scott Blair, Physics Dept., Rothamsted Experimental Station, in *Transactions of The Ceramic Society*, vol. 31, no. 3, March, 1932, pp. 79–82, 3 figs., *d*)

METALLURGY (See Engineering Materials: Inherent Characteristics of Steel)

MOTOR-CAR ENGINEERING

The Claus Diesel Engine

IN THIS engine the combustion process is controlled by variation of the combustion-chamber volume by means supplementary to the crank train.

A sectional view of the engine is shown in Fig. 1. It will be seen that within the cylinder there is a sleeve surrounding the piston, that the wall of the sleeve is thickened at the upper end, and that the flange thus formed fits a counterbore in the cylinder. The sleeve has an intermittent reciprocating motion in the cylinder, being forced up therein by a pair of cams in the crankcase, and down by the gas pressure in the combustion chamber, assisted by the force of springs surrounding its two guide pins. The cams are so designed that they keep the sleeve in its highest position in the cylinder during the greater part of the cycle; they allow it to descend through a short distance toward the end of the compression stroke, and force it up into its highest position again shortly after the beginning of the expansion stroke.

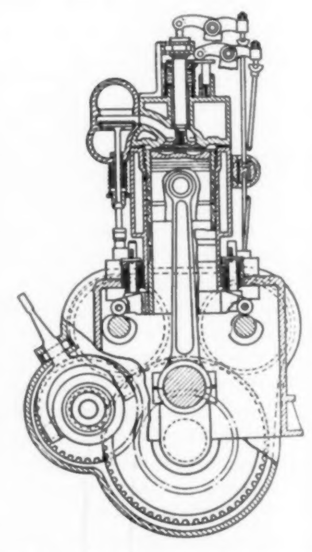


FIG. 1 THE CLAUS DIESEL ENGINE

The effect of the downward motion of the sleeve on the combustion-chamber volume is contrary to that of the upward motion of the piston; consequently when the piston is still 15 deg of crank travel from the top dead center, the combustion-chamber volume is very close to its minimum value, and the compression pressure therefore the maximum. Hence the air in the combustion chamber reaches the temperature at which the fuel ignites earlier in the cycle. When the fuel is injected, the temperature of the air in the combustion chamber being higher than in a conventional engine, the ignition delay period (ignition lag) is shortened. A diagram showing the variation of the combustion-chamber volume with the crank angle is given in the original article. Another result is that since there is no further appreciable reduction of the compression-chamber volume after the crank has come within 15 deg of the

upper dead center, the maximum pressure of combustion will be materially lower than in the conventional high-speed Diesel.

The sleeve begins to move downward when the crank is about 45 deg ahead of the top dead center, and practically the maximum compression pressure is reached when the crank is still 15 deg ahead of the top dead center. From that point on to the top-dead-center position of the crank there is practically no change in combustion-chamber volume. During this time, of course, there can be no conversion of heat into mechanical energy. The sleeve continues to move downward for some time after the dead center has been passed; during this part of the cycle the chamber volume increases more rapidly than in a conventional engine, and under conditions of equal cylinder pressure, conversion of heat into mechanical energy would therefore be at a more rapid rate. At 10 deg after dead center the sleeve reaches the bottom of its stroke, and during the next 10 deg of crank motion it is raised to the top of its stroke by the cams. During the remainder of the cycle, including the greater parts of the expansion and compression strokes and the whole of the exhaust and inlet strokes, the sleeve remains stationary in its topmost position. (*Automotive Industries*, vol. 66, no. 7, Feb. 13, 1932, p. 223, 2 figs., *d*)

Some Primary Causes of Automobile Accidents

FIELD researches carried on under the auspices of the Division of Motor Vehicles and the California Highway Patrol Board brought forth the conclusion that seldom, if ever, does the ordinary accident report reveal the primary cause of an accident.

The largest number of accidents involved collisions between two or more vehicles at a crossing intersection, and the basic or primary cause of many of these accidents seems to have been defect of clear vision. For example, on checking a number of cases there was found to exist a marked relationship between the size of the windshield corner post and intersection accidents. Many of these accidents occurred to cars having a corner post with the diagonal of 5 in. or more across the horizontal section, the post eclipsing a portion of the driver's left-side view.

The author comes to the conclusion that, as a standing rule, the best practice for safety is to keep the size of the windshield corner posts to the minimum that strength will permit. From this point of view he condemns the latest design of windshield corner posts with the base flared out for artistic effect. On many intersections protected by "stop-and-go" signals, children were killed, and a close examination of these accidents revealed that in virtually every instance in which a child was so killed the driver had absolutely failed to see the child standing or walking immediately in front of his car. The driver's eye and attention were directed to the elevated stop-and-go signal. If the driver's seat were set low, a child standing close in front of the car would not be visible.

The low seat also makes it impossible for a driver to easily see the right-hand edge of the road. Quite a number of cars that have run off the right-hand side into the ditch have low front seats. A great many cars are designed with low front seats, particularly modern sport models. Standards of seat heights should be developed if we are to approach better ideals in safe automobile design.

A surprising number of letters from victims of automobile accidents that happened at night tell of troubles they have had with the light switches on top of the steering column. While driving along the highway on a dark night and approaching a turn, the driver, in turning the steering wheel, has frequently caught his coat sleeve in the sliding light switch on the steering column and has inadvertently switched off the lights in the very act of making the turn. Traveling at a high rate of speed, cars have as a consequence run off the road and turned over or collided with objects

The light switch on top of the steering column, as a feature of modern design, has definitely been responsible for several thousand accidents, injuries, and death to riders in California during the last year.

Narrow, high windows, particularly in modern coupés and sport-model cars, are a source of danger by tending to eclipse the driver's view to the rear. The height of the side windows from the floor of the car is also a factor. The author considers next the psychological and mechanical elements involved, particularly the rapidity with which the human brain perceives sensations and responds to them, and incidentally comes to the conclusion that any speed above 40 mph is unsafe. (Victor W. Killick in the *S.A.E. Journal*, vol. 29, no. 6, Dec., 1931, pp. 470–473, *gt*)

Tractors in South and East Africa and in Rhodesia

KEROSENE is not an economically possible fuel in a country such as Rhodesia, where the rail haulage alone on a case of $8^1/_3$ imperial gallons of power kerosene from Beira lies between 4 s and 6 s according to distance, and the average price of kerosene landed on a Rhodesian farm is generally taken to be 2s or a little more, with two gallons at least being required to plow an acre of land. As a result it is stated that at least 50 per cent of Rhodesian farm tractors and probably a greater proportion in the Union are at present idle.

Crude-oil tractors have been tried with success on some farms, but their price is nearly double that of kerosene tractors, and in some cases represents more than double the initial cost of the farm. The same objection applies to steam, although steam tractors are in use on a few of the larger farms in the Colony. Suction gas would appear to be a possible solution of the problem, and tractors using such fuel form the only branch of farm machinery in which American products are not already firmly established.

In Rhodesia, wood may be had for the cutting. The importance of tractors lies in the fact that it is only by developing a cheap power capable of replacing draft animals that the menace of sleeping sickness may be conquered.

Until recently tests of suction-gas apparatus have proved disappointing, but it is said that the latest of these tests has given very encouraging results both with the tractor and the light truck. The inventor is at present in France demonstrating his machinery to the French Government; the machinery itself is now being manufactured in Salisbury, Southern Rhodesia, under the name of "High-Speed." In recent tests under the auspices of the agricultural department of Southern Rhodesia an American tractor fitted with a high-speed gas producer was used, the induction system being altered to avoid preheating the gas and the compression being increased to seven to one by means of aluminum plates on the pistons.

What is wanted would appear to be a well-built tractor of about 40 hp, with large bore, comparatively short stroke, and a low-speed engine, with two, or, better, three speeds forward and one reverse, and equipped with a gas producer which does not generate enough heat to discommode the operator, and with an adjustable track and a short wheelbase, enabling a fairly sharp turn in a radius of about 12 ft.

The article discusses the subject of design of the suction-gas tractor in a very general manner only, but conveys no information as to the specific features of the machinery tested. (*The Engineer*, vol. 153, no. 3981, April 29, 1932, p. 473, *g*)

PIPING

A Graphical Method for Determining Pressure Drop and Heat Transfer in Pipes

THE author uses a universal chart which is not reproduced here because of lack of space. He says that by its use it is readily possible to draw a few straight lines and so determine the pressure drop for any fluid, either gas or liquid, and under conditions of flow that may be either viscous or turbulent. In addition to this the chart gives film heat-transfer coefficients for liquids, optimum size of pipe with respect to cost of pipe and cost of pumping, and provides handy method for converting flow rate in one set of units into flow rate in another. Examples of the application of the chart are given. (R. A. Bayard, Mechanical Engineer, Niagara Falls, N. Y., in *Chemical and Metallurgical Engineering*, vol. 39, no. 3, March, 1932, pp. 130–132, 1 fig., *p*)

POWER-PLANT ENGINEERING (See also Marine Engineering: A Combination Turbine-Reciprocator Steam Power Plant)

The Velox Explosion Boiler

THIS boiler has been developed by the Brown-Boveri Company of Baden, Switzerland. It is, broadly speaking, a steam generator with a pressure-charged combustion chamber—in other words, something akin to a supercharged boiler. It may also be described as a gas turbine wherein the turbine proper generates only the power necessary to drive the compressor, while the main heat goes into steam generation.

In the explosion system the combustion chamber is periodically charged with an explosive mixture of fuel and air supplied to it by a compressor. On the completion of charging, with all valves closed, the mixture is ignited and the pressure in the combustion chamber rises to about 4 to $5^1/_2$ times the charging pressure. Combustion is rapidly completed, when a discharge valve placed at the ends of the heating tubes communicating with the combustion chamber opens, and the chamber begins to empty, the high-pressure gases expanding rapidly through the heating tubes. Water is circulated on the outside of these heating tubes, thus absorbing the heat contained in the gases. In this way the water is evaporated and steam generated. Meanwhile the cooled gases are led to the nozzles of the gas turbine, before which there is a certain pressure available.

When the combustion chamber is exhausted to about the charging pressure, the discharge valve in the pipe leading to the gas turbine is closed and a second discharging valve which leads to a pipe bypassing the turbine opens, as well as the admission valve through which scavenging air and a fresh charge enter the combustion chamber, the residue of the burnt charge thus being expelled from the chamber and heating tubes through the second discharge valve into the atmosphere. The admission and discharge valves as well as the ignition appliances are operated by oil under pressure, and it is interesting to note that the frequency of the complete cycle is between 40 and 60 per min, according to the size of the combustion chamber.

From the foregoing description it will be appreciated that due to the explosion of the compressed charge of mixture, a pressure drop is obtained without additional external mechanical work, thus imparting to the gases a high velocity in the heating tubes as well as providing energy which is used in the gas turbine. The gases are said to give up the whole of their sensible heat to the tubes for the purpose of generating steam, and are thus cooled off before they reach the turbine, in which they are further expanded and cooled in doing useful work in driving the compressor.

The overall dimensions of the equipment are said to be small. The separation of the steam for the circulating water is effected by means of special centrifugal separators, of which either one or two in series may be used, and for which the circulating pump supplies the necessary pressure drop. After separation the steam goes to a superheater which is placed in the combustion chamber of the explosion-type boiler. The steam-generator plant usually consists of several chambers, each with its own separator and superheater, while the circulating pump for driving water through the steam generators is common. (*The Marine Engineer and Motorship Builder*, vol. 55, no. 655, Apr., 1932, pp. 125–127, 2 figs., *d*)

Modern Boiler Plant

THIS paper deals primarily with British conditions, but makes occasional reference to American developments. The most interesting part is that dealing with factors in design affecting reliability and operation. This section of the paper is subdivided under the following headings:

(*a*) Water-heating and evaporative parts (boiler and economizer)
(*b*) Superheater
(*c*) Combustion chamber
(*d*) Combustion equipment.

Under (*a*) the author discusses the trend toward higher ratings and the results accruing from such practice. He suggests that the conventional present-day boiler form is unsuitable for the development of high rates of heat transfer, and that such rates can only be effected by radiant heat, necessitating very radical changes in boiler-unit form. He suggests, in general, that for the commonly accepted boiler-unit forms the average rate of evaporation per square foot of total water-heating surface at normal load should not exceed 5.5 lb per hr. The need for further development of soot-blowing apparatus is discussed under this subheading.

Under (*b*) the trend in superheater design is discussed, and the vulnerability of the modern superheater location is emphasized. It is suggested that with the demand for still higher superheats, development in design is necessary to provide a superheater location where definite and separate control of superheat temperature can be effected. Superheater troubles within the experience of the author are given, and these include records of temperatures which superheater tube materials have to withstand in every-day practice.

Under (*c*) the author discusses and emphasizes the importance of combustion-chamber design, and suggests that the boiler parts proper should be designed and arranged in dependent relation to the combustion chamber. The development of the water-cooled combustion chamber is briefly outlined, and its various advantages and limitations are discussed. The form of the combustion chamber and factors affecting reliability of refractory and water-wall construction are also discussed.

Under (*d*) the author deals with the relative merits of stoker and pulverized-fuel combustion equipment, and suggests that pulverized-fuel firing has many advantages over stoker plant. These advantages are discussed, but the suggestion is qualified by the necessity for designers, constructors, and operators being thoroughly conversant with the subject of pulverized-fuel-plant design and operation.

This section is followed by a discussion of the relative merits of the unit and bin-and-feeder systems of pulverized-fuel plant, and the author suggests that the greater reliability and other advantages of a form of bin-and-feeder system cannot be ignored.

It is suggested that the adoption of boiler units of greater capacity for the modern large generating station has many advantages without sacrificing reliability or incurring greater costs, and a further suggestion is made and briefly discussed in favor of pulverized-fuel-fired units of not less than 500,000 lb of steam per hour.

Air-heater equipment is discussed in this section of the paper, and the author criticizes and discusses modern designs. He suggests simplicity in form and construction, and greater attention to the laws governing the flow of air and gases. A brief survey of one phase of the author's experience in the application of high-temperature air to stoker practice is given and conclusions are reached. These latter are principally the necessity for cooling the grate surface to at least 350 F and limiting the air temperature to this value. This section concludes with a survey of the author's experience with a large pulverized-fuel installation. (John Bruce in a paper before the *Institution of Electrical Engineers*, London, read Mar. 10, 1932, abstracted from proof sheets, 37 pp., 16 figs., *dg*)

Motion of Gases in the Smokestack

A MATHEMATICAL investigation of the motion of gases would indicate that a gas bubble rising in free air moves substantially in accordance with the laws of free fall of bodies as illustrated by the Atwood machine, and in the original article the author derives an equation (No. 2*a*) covering this situation. In the case of a smokestack, however, the behavior is different. Here the gases are produced continuously, for example, in a furnace, and only the amount of air is drawn in that is necessary for combustion (which of course includes the excess air). Because of the fact that the firing process occurs between the suction of the air and the ascent of the gases, a circular process is brought about embodying the following phases: 1, Suction of cold air; 2, expansion of air at constant pressure (firing); 3, elevating the gases to the height h of the stack; and 4, cooling the gases after their exit from the stack. If L is the weight of the air handled per second, the work done in one second in handling it is equal to $Lw_e^2/2g$, where w_e is the velocity of the air flow. Similarly, the work required to elevate the gas is equal to $Gw_2/2g$, where G and w_2 are respectively gas weight and velocity. In the second stage there is added to the gas as a result of the combustion process the work of expansion

$$Gp_1(v_2 - v_1) = Gp_1 \frac{\gamma_e - \gamma}{\gamma_e \gamma}$$

Likewise in the fourth stage the work of expansion

$$Gp_2(v_2 - v_1) = Gp_1 \frac{\gamma_e - \gamma}{\gamma_e \gamma}$$

will be subtracted, so that the total work available is

$$G(p_1 - p_2) \frac{\gamma_e - \gamma}{\gamma_e \gamma}$$

But

$$\frac{p_1 - p_2}{\gamma_e} = h$$

which is the difference of level between the second and fourth stages of the process. Hence the work available during a second can be written as

$$Gh \frac{\gamma_e - \gamma}{\gamma} = Vh(\gamma_e - \gamma) \ldots\ldots\ldots\ldots [3]$$

which is none other than the well-known expression for the energy necessary to lift the gas. The accelerations which have to be accounted for from this source of energy are those comprised within the first and third stages, and are given by the equation

$$L \frac{w_e^2}{2g} + G \frac{w^2}{2g} = Gh \frac{\gamma_e - \gamma}{\gamma} \ldots\ldots\ldots\ldots [4]$$

where γ_e is the specific weight of air and γ the specific weight of the gas. The members on the left-hand side of the equation comprise all the resistances and losses occurring in the practical operation of a smokestack, because all of them must be met by

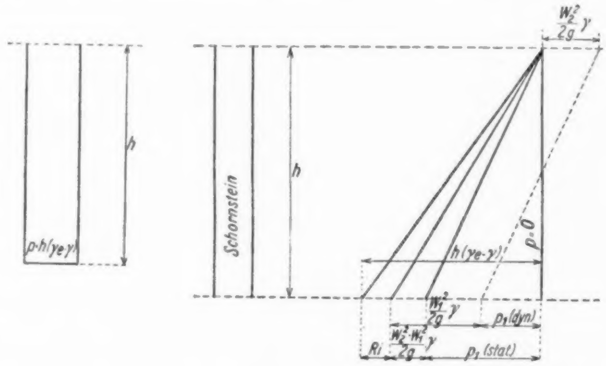


FIG. 2 LEFT: DIAGRAM OF SMOKESTACK CLOSED AT THE BOTTOM AND FILLED WITH GAS. RIGHT: DIAGRAM OF STATIC AND DYNAMIC PRESSURES IN A SMOKESTACK

the supply of energy represented by the right-hand side of the equation. To represent the same condition in the usual terms, the author combines the energy required for air and gas suction together with all the other resistances W_1 located ahead of the entrance to the stack, and expresses the sum of the draft Z in the stack by

$$Z = W_1 + \frac{L}{G} \times \frac{w_e^2}{2g} + \frac{w_1^2}{2g}$$

As regards the stack itself, account must be taken of the increase in the velocity of the gas, namely,

$$\frac{w_2^2}{2g} - \frac{w_1^2}{2g}$$

and the frictional resistance R_i, so that the following is obtained:

$$h \frac{\gamma_e - \gamma}{\gamma} = Z + \frac{w_2^2 - w_1^2}{2g} + R_i \text{ kgm per kg} \ldots [5]$$

The factor $(\gamma_e - \gamma)/\gamma$ in Equations [4] and [5] is always positive, and the acceleration that can be attained depends only on the difference between the specific weights of the air and the gas; under these conditions the acceleration g due to gravity can be considerably exceeded in this case but not in the case previously considered (i.e., of a bubble of gas rising in free air). This is due to the fact that the smokestack process is a regulated thermal cyclic process unlike the simpler case of the rise of a gas bubble in free air. Equations [4] and [5]

apply of course only to the case where normal operation has been attained. In firing up, before the cyclic process has been properly established and hence while there is still cold air present in the stack, the latter must be expelled therefrom before the gases can attain their proper velocity. This is expressed by saying that the smokestack does not yet "draw." The energy available for the smokestack process manifests itself as the pressure difference between top and bottom of the stack. From this the author proceeds to consider the limiting conditions. The first is when the stack is completely shut off at the bottom, but remains filled with gas.

Then in accordance with Fig. 2 there is a suction amounting to $h(\gamma_a - \gamma)$. In this case the smokestack becomes a device whose purpose is to transfer the pressure at the height h to the level $h = 0$, so that the upward-acting energy at the base of the stack can be utilized as pressure energy. Since, however, there is a column of gas in the stack of height h and specific weight γ, a full difference in air pressure does not appear, but only the part

$$p_1 - p_2 = h \times (\gamma_a - \gamma)$$

The same applies in the case of a stack closed at the top and filled with gas from below. In that case there will prevail in the stack a gage pressure expressed by

$$p_2 - p_1 = h \times (\gamma_a - \gamma)$$

A small nozzle which may be built in the damper either at the bottom or at the top of the stack will cause the development of the following velocities:

$$\frac{w^2}{2g} = \frac{h(\gamma_a - \gamma)}{\gamma} = \frac{p_2 - p_1}{\gamma} \quad \text{or} \quad \frac{p_1 - p_2}{\gamma}$$

This nozzle, however, must be so small that there will be no noticeable flow from it into the stack. If the stack is open so wide that there is a considerable flow through it, then a distinction must be made between "static" and "dynamic" pressure, since in general the "dynamic" pressure will exceed the "static" pressure by the amount of the velocity head. The friction created by the flow in the stack must then also be considered. From what has been said above it would appear that the pressure relations in an actual smokestack are as follows (the velocity at the entrance to the stack being w_1 and at the exit, w_2):

1 At the entrance:

Static pressure: $$- h(\gamma_a - \gamma) + \frac{w_2^2 - w_1^2}{2g}\gamma + R_i \text{ mm of water}$$

Dynamic pressure: $$- h(\gamma_a - \gamma) + \frac{w_1^2}{2g} + R_i \text{ mm of water}$$

2 At the exit:

Static pressure: 0

Dynamic pressure: $$+ \frac{w_2^2}{2g}\gamma \text{ mm of water}$$

These relations are graphically presented in Fig. 2. The corresponding diagram in Schumacher's "Auftriebsverhältnisser bei Feuerungen unter besonderer Berücksichtigung der Gasfeuerstätten," München und Berlin, 1929, p. 17, is not correct, as Schumacher assumes the dynamic pressure at the exit to be equal to zero. The original article is accompanied by a table giving the specific gravities of stack gases for various contents of carbon dioxide and water vapor. (Dr. of Engg. Arthur Zinzen in *Feuerungstechnik*, vol. 20, no. 3, Mar. 15, 1932, pp. 34-36, 3 figs., *t*)

THERMODYNAMICS

The Properties of Steam

AN EDITORIAL under this title deals primarily with Dr. Max Jakob's lectures on steam research which were delivered in May, 1931, and were abstracted in MECHANICAL ENGINEERING, Vol. 54, Nos. 4 and 5, April and May, 1932, pp. 282 and 356. It takes up, however, several other subjects, of which only the following can be referred to here.

The most remarkable instance of the effect of small impurities in water is to be found at the critical point. In this connection the writer thinks exception may well be taken to some observations made in a paper read at the World Engineering Congress at Tokyo in 1929 by Messrs. Davis and Keenan. These authors asserted that Callendar's measurements, "though valuable," were not of high enough precision "to distinguish between an isothermal with a flat segment and the very slightly curved isothermal which the accepted theory would predict in this region. We therefore," they continued, "see no reason for abandoning the traditional point of view as to what happens at this critical point."

Now, the fact remains that Callendar's experimental disproof of the traditional view is quite independent of the precision of his measurements. If any ordinary "pure" organic liquid is heated some 50 deg above its critical point and then watched while it cools, the whole mass is seen to be traversed by striae passing from one end of the tube to the other, and near the critical point rapid fluctuations in density are made evident by opalescent effects. Finally, just as the critical point is reached the whole tube fills with a dense fog, which is followed by the appearance of a meniscus and the separation of the liquid and vapor phases. With impure water quite similar appearances can be observed, but if special precautions are taken to secure purity, the phenomena change completely. The meniscus disappears and reappears without a trace of turbulence or opalescence. The absence of the latter phenomenon would of itself almost suffice to discredit the traditional theory, since the mathematical investigations of Einstein and Smoluchowski show that this opalescence arises from minute changes in density, which must inevitably arise at the critical point if the ordinary theory is valid.

Moreover, the important fact remains that when the temperature was raised above 374 C, at which the meniscus disappears, Callendar was still able to trace a line or band of demarcation between the contents of the upper and lower sections of his tube. Further, he found that while the two varieties could be mixed by agitating or inverting the tube, they separated out again into two distinct portions when given time.

All these observations, it will be noted, depend in no way on precise measurements, any more than does the distinction in color between sky and sea. New and more precise measurements may quite conceivably involve corrections in the specific volumes which Callendar attributed to the liquid and vapor phases at temperatures of more than 374 C, but his purely qualitative observations suffice to show that at this temperature the specific volume of the vapor is not the same as that of the fluid.

The following may also be of interest. Physical conditions seem to demand that, as Callendar claimed, the molecules of steam at zero pressure must be represented by H_2O. If, for example, we had one molecule of steam in a cubic centimeter of air at normal temperature and pressure, the partial pressure of this molecule would be sensibly zero. If, as Perrin has claimed, dissociation is effected solely by radiation, any compound molecule such as, say, H_4O_2 would soon be broken

up into two molecules of H_2O, and it would then, in all probability be hundreds of years before the two met again and attained the opportunity of reassociating. At normal temperature and pressure there are about 2.7×10^{19} molecules in a cubic centimeter of air, and though each molecule makes about 5×10^9 collisions per second, it would take ages for any one molecule to meet any other which might be specified.

If, therefore, water vapor at zero pressure consists of single molecules, it would seem that any variation in the specific heat with changes of temperature can be due only to an absorption of radiation. Possibly this is too extreme a view, since in a recent issue of *Nature* the claim is made that at about 140 C the molecule of CO_2 changes from a bent to a straight form in which all three atoms lie in a line. Even so, however, this change may well be due to an absorption of radiation. (Editorial in *Engineering*, vol. 133, no. 3452, Mar. 11, 1932, pp. 317–318, *p*)

TRANSPORTATION

The Biway Moving-Walk System of Transportation

IN THIS system, a modification of the moving sidewalk is intended to take the place of the present subway system. It consists, first, of a continuous stationary platform entirely around the loop served by the system. Next to this platform is the local or transfer platform, also continuous, which stops to receive passengers every 50 sec. Between stops it reaches a speed of 17 mph, which is the speed of a second continuous platform known as the express train.

Passengers board the first of the moving platforms or belts of cars at any point. When it is moving at the speed of the second parallel platform, gates open and they enter the express, where they remain for the trip. Between its meetings with the local platform, the speed of the express increases to 22 mph. It never stops. There is a loading and a transfer every 50 sec. Since each of these movements lasts 10 sec, no one ever waits for a train more than 40 sec.

The cars are each 12 ft long, and their ends are so curved that the cars will move around sharp curves without separating. There is only one pair of wheels under each car, and these are placed near one end. The weight of the free end is carried by the wheels of the next car. Tracks are greased to lessen the noise, and there are no brakes or loose parts to rattle.

The driving motors are stationed beneath the tracks at intervals of about 1000 ft. Running lengthwise beneath each train is a T-section, the flange of which runs between the driving wheels of the motors. There are no motors on the trains themselves, and the wheels do not do the driving. The axles carry longitudinal T-rails through which the whole driving is effected, and sets of motors propel the drive wheels which are braced against the flanges of the T-rails. It is therefore purely an adhesion drive. A resilient type of track construction is to be used to lessen maintenance and to cushion shocks, as well as deaden noises. Greasing the rails will make for quiet operation. It is claimed that the Interborough Seventh Avenue Subway in New York furnishes only 24,500 seats an hour passing a given point, and even with 58,200 standing passengers the total capacity would be 8000 an hour less than the estimated number of seats on the Biway.

Stations in the present sense will be completely eliminated. Entrance at the street will be at intervals of 100 yd or less. It is claimed that since passengers can board the Biway at any point, crowding at stations will be eliminated. Electric signs will be provided in each car to tell passengers where they are and when to transfer to the local in order to get off nearest to their destinations. (Norman W. Storer in a press service release by the Westinghouse Electric and Manufacturing Co., A-61197, 9 pp. of text, 2 pp. of illustrations, *d*)

WELDING

Westinghouse Device for Studying the Corrosion of Welds

THE effect of corrosion is becoming so important in welded boilers, pipes, and containers for oil and chemicals that the Westinghouse Research Laboratories are studying it with special apparatus. In welded structures of rustless steel, alloys, or monel metal this problem is vital. The results of these studies may tell engineers how to fabricate structures so that all parts will be uniformly resistant to rust.

In a weld of low-carbon steel, corrosion may be expected to start in the zone where weld metal meets parent metal. At this point, according to the electrolytic theory of corrosion, a potential difference may exist which is responsible for an accelerated attack. Oxides and other heterogeneous particles, if present in the weld, tend to hasten corrosion by the formation of electrolytic cells. The soil corrosion of pipe lines is an example. A more homogeneous weld should be expected with coated welding wire than with bare electrodes, since the coating resists the entrance of foreign elements.

To corroborate many facts already known on this subject and to uncover others, a special corrosion device has been built which greatly hastens the slow process of rust. In it the test specimens are subjected to intermittent immersions in a corroding liquid. The apparatus suddenly immerses the samples for a definite period, leaving them at rest, and then removing and exposing them to air for a definite period. They are moving only when being lowered or raised—a period of time which is a very small fraction of the cycle.

Samples are suspended from a rack by glass hooks, horsehair, or silk, and a motor-driven crankshaft raises and lowers the rack. The driving motor is controlled by a timing device composed of a synchronous motor operating a contact, which causes the motor to periodically turn the crankshaft a half-revolution. The timing can be set for any cycle of test operation. To obtain reproducible results the corrosive liquids are kept at a constant temperature by circulating water of a constant temperature along the outside of the vessels containing the corrosive liquids. (*Westinghouse Technical Press Service*, A-61021, 2 mimeographed pages, *d*)

Experimental Report on Welds

TO TEST welds for defects the British Engine, Boiler, and Electrical Assurance Co., Ltd., has recently made a few trial examinations of welds specially prepared by the Straight Away weld-testing method originating in Germany. The method has the advantage that, on account of its simplicity, it appeals directly to any engineer or manufacturer. The special apparatus consists of an electrically driven vertical milling machine, which is tack-welded on to the top of the joint. It merely mills a hole in any position of the joint, and a forward travel makes the hole oval and allows an increased area of weld metal to be examined. It is a simple matter afterward to fill in the hole with fresh weld metal. The hole, when made, can, if so desired, be etched up to make evident the various runs of metal and the junction of the weld and the parent metal.

This method of testing welds appears to have good possibilities for practical application, but the surface of the holes

in the angle welds and the reinforced butt welds was too rough to allow detection of minute defects. In this case the specimens were small and of awkward shape, so that the machine was not attached to the welded part as intended.

Welds were broken in tension. When viewed under the microscope the defective parts were found to consist of coarse grains of ferrite containing a nitrogenous constituent giving the suggestion of a Widmanstätten structure. At the remainder of the surface the nitrides were retained in solution.

A special form of interleaved joint used in America (Fig. 3) for pressure vessels was tested, and it was concluded that this type of joint does not appear to have anything to recommend it. It encourages the entrapping of slag at the bottom of the V. The underside of the V-weld in a pressure vessel should always be accessible for inspection, and it is desirable that slag should be cut away on that part, after which a wash run of metal should be applied.

The possibility that the heat of welding will bring about deterioration of the metal surrounding a weld often arises, and as injury is likely to be more pronounced as the carbon content of the plate is increased, it was decided to see to what extent deterioration could be shown up by means of notched-bar impact tests.

The tests, owing to the comparatively small depth of the part where the structure was altered when compared with the depth of the specimen, were insufficiently delicate to show the full effect of any change. This gave conclusive evidence, however, that marked change can occur. To what extent changes do occur will naturally depend to a certain extent on chance and special circumstances, such as the initial condition of the plate with respect to heat treatment, the variation in penetration, the current used for the various runs, the plate thickness, and the general design. Any reduction of impact value depends more on the time during which an area may have been heated to an excessive temperature than it does on the maximum temperature attained. Though greater depreciation is likely to follow with shell-quality plate than with furnace-quality, it does not follow that there will be any at all. With the proviso that the local part of the plate may easily be adversely affected, and the defect not shown up by a test, either quality of plate may be improved, owing to refinement of the grain. This, however, may be counterbalanced if the metal is chilled.

Though the tests show that with oxyacetylene welding there may be a noticeable improvement with both qualities of plate, it must always be remembered that this does not show that the whole of the specimens are improved, and a very different result may be obtained with a test made to show the energy required to cause an initial crack at any part of the specimen. Judged by the test figures, it would not be safe to predict that, in practice, the change in shock value will be greater or less with any particular form of welding than it is with any other form. Any change depends largely on the original condition of the plate. Naturally, it is to be expected that an oxyacetylene weld will always be the most adversely affected, owing to the greater volume of overheated metal. On the other hand, with metallic-arc welding and a plate having initially a large grain size, it is reasonable, especially when the current has been low, to expect general improvement, but no general law can be given. Even where there is general improvement there may be some small area of the plate, especially near the top of the V, where the metal has locally been maintained at a sufficiently high temperature for it to have an overheated structure.

The tests do show that, however much a specimen may be adversely affected, the damage with any of the forms of welding tested does not extend an appreciable distance into the plate. Though in some instances they show very marked depreciation, in no instance do they indicate that really serious damage has occurred. Naturally these results must not be applied to plate containing a higher carbon content.

A large number of tests were made on overhead and vertical welding. With metallic-arc welding the situation may be summarized as follows:

With an overhead weld there is the most difficulty in obtaining penetration to the back of the plate.

With a heavily coated electrode, provided that a suitable covering is used, it is possible to lay good-quality weld metal when the plate lies overhead, or is vertical with the weld horizontal. Judged, however, by the results obtained, uniform success is not to be relied upon, and it is highly probable that the metal will not reach the back of the plate, which may be inaccessible for a wash run.

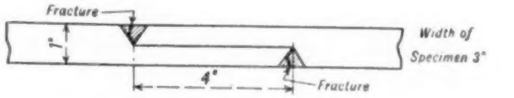


FIG. 3 INTERLEAVED WELDED JOINT

With a lightly coated electrode, the danger of entrapped slag is decreased, and when the plate and weld are both vertical better penetration to the back of the plate and more uniform weld metal are to be expected. Naturally, however, the metal during its passage through the arc is likely to be more contaminated by the atmosphere than when a more heavily coated electrode is used.

With a bare-wire weld, troubles due to slag are avoided, but greater skill is required on the part of the operator. Though it is not to be expected that the ductility, the shock value, and the penetration will be so good when an ordinary bare wire rod has been used, the tests have shown that, though oxide inclusions may be present, sound metal can be laid for each type of weld, and, in fact, the Izod values for vertical and overhead welds need be no lower than they are for horizontal welds.

In general, for vertical and overhead welds, especially the latter, oxyacetylene is more difficult to apply than metallic-arc welding, but the metal can be laid satisfactorily by an experienced operator. When the weld is accessible at one side of the plate only, poor or irregular penetration must be anticipated, and an inferior finish is to be expected.

The subjects of contour of fillet welds and the use of bare wire in the metallic-arc welding of pressure vessels were investigated. With bare wire certain faults have been found which refute the claim that bare-wire welds are necessarily free from serious inclusions. The principal objection to such welds as ordinarily made lies, however, in their low impact value.

As regards heating of electrodes, it is said to be a mistaken notion that when an electrode is connected to the positive pole it necessarily becomes hotter than when it is connected to the negative, and that for this reason the slag covering becomes more fluid. In general, heavily coated electrodes are connected to the positive pole and bare-wire or lightly coated electrodes to the negative. The relative heating of the two poles was found to depend to a material extent on the composition of the rods. (Technical Report for 1930–1931 of the British Engine, Boiler, and Electrical Insurance Co., Ltd., abstracted through *The Engineer*, vol. 153, no. 3983, May 13, 1932, pp. 527–528, 1 fig., *d*)

SYNOPSES OF A.S.M.E. PAPERS

THE papers abstracted on this and following page appear in the current issues of the Machine Shop Practice and Wood Industries sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering." Copies of the Transactions papers may be obtained by those not registered in these Divisions by addressing the Secretary of the A.S.M.E., 29 West 39th Street, New York, N. Y.

MACHINE-SHOP PRACTICE

Automatic Internal Grinder

INTERNAL grinding, originally a toolroom operation, has been demanded for such a large number of parts that it has become necessary to develop machines that will grind the holes at the lowest possible cost. This development has culminated in the automatic internal-grinding machine which positively determines the size of the hole and which requires no gaging on the part of the operator, who merely puts the work into the chuck and starts the cycle of operations. The improvements on the machines and their adaptation for special grinding jobs are described. (Paper No. MSP-54-1, by H. L. Blood.)

Performance of Cutting Fluids

THIS paper presents the results of a series of experiments to determine the influence of eleven different cutting fluids on the power required to plane and drill an annealed S.A.E. 3150 steel.

This investigation was conducted as a project of the Subcommittee on Cutting Fluids of the A.S.M.E. Special Research Committee on the Cutting of Metals, by the Department of Engineering Research of the University of Michigan, with funds provided by Engineering Foundation, and the paper forms its third progress report. The object was to secure definite performance data for certain limited conditions as a preliminary step to a comprehensive study of cutting fluids.

The force required to cut metal by planing for a single tool shape was determined for a variety of feeds and depths of cut. A formula for the planing force is developed as a function of the cutting fluid, the depth of cut, and the feed as $P = CD^{0.95}f^{0.79}$. (Paper No. MSP-54-2, by O. W. Boston and C. J. Oxford.)

Preloaded Ball Bearings as Applied to Machine-Tool Spindles

IN ATTAINING precision of operation of machines fitted with ball bearings, after all initial looseness had been removed and dimensional tolerances held to very close limits, it was found that another factor remained which prevented attaining the high degree of accuracy of dimension and finish required of precision machine tools. This was that elastic deformation in the ball bearing had a great effect on quality. The cure was effected by preloading, this initial loading serving to remove all looseness between the balls and the raceways, as well as the more objectionable effects of the early deformation that develops in a ball bearing under load. The proper value of the preload can be determined only after full consideration of the work loads involved. (Paper No. MSP-54-3, by H. E. Brunner.)

Influence of Chemical Composition and Heat Treatment of Steel Forgings on Machinability With Shallow Lathe Cuts

THE tests described in this report were made primarily as a study of lathe-tool performance with shallow cuts as affected by variations in chemical composition and heat treatment of the steels cut. The cutting tests were made dry with high-speed-steel tools of a selected size, form, composition, and heat treatment, with a feed of 0.0115 in. per rev. and 0.010 in. depth of cut. Comparisons were made of the Taylor speeds on the basis of equal tensile strengths when cutting 0.4 per cent carbon (S.A.E. 1040), chromium-vanadium (S.A.E. 6140), nickel-chromium (S.A.E. 3140 and 3435), chromium-molybdenum (S.A.E. 4140), and $3^1/_2$ per cent nickel (S.A.E. 2340) steel forgings heat treated to give tensile strengths between 75,000 and 220,000 lb. per sq in.

The study also included consideration of the surface finishes of the various steel forgings as affected by the test conditions, the microstructures of the steels cut, and tool performance as affected by the additions of from 3.5 to 11.7 per cent cobalt to the customary 18 per cent tungsten type of high-speed tool steel.

Of the different steels cut in the lathe tests, the plain carbon steel was the most difficult to machine other than an annealed nickel-chromium steel.

The results showed that the effect of changes in chemical composition of steel forgings upon their cutting speeds was dependent upon the tensile strength at which the comparisons were made. In the different steels cut with shallow cuts the most effective special alloying elements for improving machinability were the combinations of nickel and chromium or chromium and vanadium for the high tensile strengths in the neighborhood of 180,000 lb per sq in., while chromium and molybdenum were the most effective in the lower range of about 90,000 lb per sq in. (Paper No. MSP-54-4, by T. G. Digges.)

WOOD INDUSTRIES

Development of Wood Adhesives and Gluing Technique

STUDY of adhesives used in furniture and other relics of earlier civilizations yields little of value to present-day craftsmanship. This paper therefore discusses only the more recent developments in glues and the technique of using them. While some glues are of ancient origin, modern large-scale production and more precise controlled methods have resulted in glues of higher and more uniform quality than the ancient glues from the same sources. Standardization of tests and testing methods is important. Joint tests constitute the principal means for determining the suitability of glues for

woodworking. Tests that can be made directly upon the glues rather than upon glued joints may be developed. (Paper No. WDI-54-1, by T. R. Truax.)

Merits and Applications of Animal Glue to Veneer Work

THE growing use of crotch, burl, and stump veneers has added to the technical difficulties of fine-furniture manufacturing. Animal glue for manufacturing fancy veneered work has properties commending it to the plywood maker, such as (1) its fluidity, giving a moderately large spread in highly concentrated solution; (2) its neutral reaction and chemical inertness, which make it incapable of staining delicate face veneers; and (3) its quick-setting and fast-drying tendencies, which permit prompt pressing. Modern processes of sizing and gluing are described. The veneering operation is analyzed from the standpoint of (1) the large area of wood surface to be covered with glue, (2) the large proportionate amount of moisture absorbed by the wood from the glue, (3) the short distance from the glue line to the surface to be finished, (4) the comparatively long assembly time, (5) the emphasis on beauty of appearance in the fabricated article, (6) the need for speed of production, and (7) the importance of quick and proper drying. The conclusion is reached that animal glue has kept pace with the industry and is well qualified for the highly decorative, if somewhat difficult, veneering processes of today. (Paper No. WDI-54-2, by Wilbur L. Jones.)

Vegetable Glues

THIS paper gives essential information about vegetable glues and the gluing of wood with them, considering veneer glue, joint glue, and liquid glue. There have been recent developments in vegetable joint and liquid glues that are not generally known, and the paper covers these in a practical rather than in a technical manner, intending to be of assistance in commercial operations. The paper describes a vegetable glue that has a carbohydrate as its base and is a practical glue for use in the woodworking industries. (Paper No. WDI-54-3, by Albert B. Maine.)

Casein Glue

CASEIN glue, made from soured skim milk, then dried, ground, and blended, has been in use in Germany for 50 years and in the United States for 30 years, but it was not until the World War period that it came into general commercial use. It was then that easy-to-use formulas of standard type were developed for the production of waterproof plywood in airplane construction. It now has general use in the woodworking industry. Casein glue in the past has relied upon harsh alkalis as water-proofing agents. The casein glue of the future for veneering will be relatively only slightly alkaline, but will be high in water resistance through the addition to the dissolved glue of a chemical solution. The smaller user will have a glue that will carry overnight without loss of strength, will be quick setting and strong, and will have sufficient water resistance for ordinary needs. (Paper No. WDI-54-4, by W. F. Leicester.)

Blood Albumin and the Woodworking Industry

BLOOD-albumin glue is probably the latest commercial adhesive. Blood albumin is a complicated mixture composed mainly of hemoglobin, serum albumin, and serum globulin, together with small amounts of sugars, fats, salts, coloring matter, and other substances normally found in blood. Its main characteristic is its ability to form an irreversible gel when its water solution is heated to 160 F. The first use of blood-albumin glue apparently was in the making of plywood canoes. The World War created an intensive demand for water-resistant plywood glues, and much of it was used in airplane and boat construction. Its source is beef blood as a by-product of the packing-house industry. It is essentially a hot-press glue. There are several types, all a mixture of blood albumin, water, and an alkali. (Paper No. WDI-54-5, by C. B. Smith.)

Oil-Seed-Residue Glues

THE paper describes the history, characteristics, uses, and limitations of soya-bean glue, or generically of seed-residue glue. This is the newcomer in the glue field, its use practically dating from 1923. The adhesive base of the seed-residue glues is the cake or meal resulting from the oil-pressing of soya beans, peanuts, cottonseed, etc. In the manufacture of plywood it is stated that the tonnage of the oil-seed-residue glues equals that of any other type of glue. In connection with the soya-bean glues there has been developed the use of carbon bisulphide as an agent to increase water resistance. The chief uses of these glues at present are for Pacific Coast fir and pine plywood, on which they are used exclusively; for box shooks in the eastern and southern states; for drawer bottoms, glass backs, etc., in the furniture field, and for the lamination of fiber insulating board. (Paper No. WDI-54-6, by I. F. Laucks and Glenn Davidson.)

Manufacture and Uses of Fish Glue

THIS paper briefly describes the process used in the manufacture of liquid fish glue. It also mentions the field of application of this glue and the technique for using it. (Paper No. WDI-54-7, by A. G. Brooks.)

How Dry Should Wood Be for Various Industrial Uses?

THE testing of wood for industrial uses is stated to be best made on its moisture content. Much wastage in manufacture is declared to be due to lack of knowledge of this fact, and the consequent antiquated test methods in use in the wood-goods manufacturing industries. The effect of climate on the ideal moisture content is said to count for little. Furniture, flooring, and other products are dried to about 6 per cent wherever manufactured. A table is given of the equilibrium moisture content of wood at various atmospheric conditions, and also a table of the dryness requirements for a wide variety of wood products. (Paper No. WDI-54-8, by H. L. Henderson.)

Some Observations on Raised Grain

WOODWORKERS and finishers are confronted with certain difficulties classed under the category of "raised grain" which, so far, have resisted satisfactory solution. This paper describes some observations on raised grain that may lead to a better understanding of the problems and which may suggest approaches toward overcoming them. Casual investigations made of raised grain suggest some remedial measures, and indicate that there is a large field for research connected with the surfacing of lumber, both as to the cause of the objectionable features encountered and methods of overcoming them. A microscopical study of the way that present day woodworking tools and machinery cut wood and the development of new equipment which would give more nearly ideal results, seem to offer possibilities which would go a long way in improving wood products or reducing their costs. (Paper No. WDI-54-9, by Arthur Koehler.)

THE LANGLEY FIELD CONFERENCE

Scientific Staff of the N.A.C.A. Reports Results of Many of Its Recent Aeronautical Investigations

By ALEXANDER KLEMIN[1]

THE Seventh Annual Aircraft Engineering Research Conference met at Langley Field, Virginia, on May 25, at the laboratories of the National Advisory Committee for Aeronautics. The meeting was as usual attended by representative engineers and executives of the Government air services and of the aviation industry in general. This annual conference has two main purposes: one to acquaint the industry with the scientific progress made by the scientific staff of the Committee; the other to permit the industry to suggest further research work to the N.A.C.A.

The N.A.C.A. has now completed and put into active service several major pieces of equipment, among them being its full-scale wind tunnel (the largest in the world) and its model towing basin (also the world's largest).

INCREASE OF LIFT

One of the outstanding points of the program was the presentation of results of a systematic series of tests on a variety of lift-increasing devices.

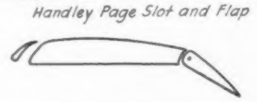
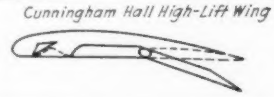
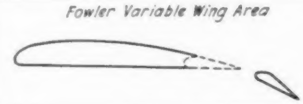
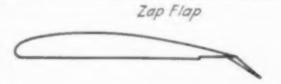
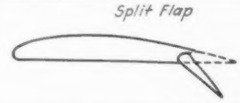
The subject of lift increase has attracted the attention of inventors, designers, and university and other laboratories for many years. By lift increase is meant increase in the maximum lifting capacity of the wing. For an airplane of given weight, the minimum speed is proportional to the inverse root of the maximum lift coefficient. Therefore from an increase in maximum lift coefficient there follow an important number of effects: decrease in landing speed; decrease of the landing run; ability to come in over a steep obstacle into a restricted field, etc. The Guggenheim Safe Aircraft Competition held at the end of 1929 for the purpose of securing an aircraft with better slow-speed characteristics, achieved its purpose since the winning plane had a better ratio of high speed to low speed than was then accepted practice. This Competition also gave a practical test to a number of lift-increasing devices.

It is strange however, that the Competition was not followed by practical service use of such devices, and the N.A.C.A. is to be congratulated in bringing renewed attention to them and in undertaking their systematic and comprehensive investigation.

In Table 1 are given the main results of this investigation, together with thumbnail sketches of the appliances. All the tests were made with the well-known Clark Y-profile as the basic section. The results of the N.A.C.A. are supplemented, for the sake of completeness of comparison, with some of those obtained in the laboratories of New York University, whose work on these high-lift devices appears to check very closely with that of Langley Field.

The second device in the table, the fixed front auxiliary airfoil (sometimes termed the Leigh slot), is very simple, consisting of an auxiliary wing placed ahead and above the main wing. In its optimum position the auxiliary front airfoil adds about

TABLE 1 LIFT-INCREASING DEVICES

Wings	C_L max.	α for C_L max.	C_L/C_D at C_L max.
Clark Y 	1.240	14°	10
Fixed Auxiliary Airfoil 	1.705 on Total Area	24°	3.62
Handley Page Slot 	1.840 on Basic Wing Area	28°	4.27
Handley Page Slot and Flap 	2.16 on Basic Wing Area	20°	3.82
Cunningham Hall High-Lift Wing 	2.05 on Wing Area	13°	3.96
Fowler Variable Wing Area 	3.17 on Basic Wing Area	15°	4.24
Zap Flap 	2.52 on Basic Wing Area	13°	3.50
Split Flap 	2.03 on Basic Wing Area	10°	3.05

32 per cent to the lift of the basic Clark Y-section. It is true that the minimum drag of the combination is greater than that of the basic wing, but the all-around effectiveness, which is measured by the ratio of the maximum lift coefficient to the minimum drag coefficient, is about 21 per cent greater than that of the Clark Y. The increase in lift is explainable on the following grounds: When a wing is at too large an angle to the wind it burbles or stalls, and the lift is destroyed. The auxiliary airfoil, by a species of venturi action, provides additional energy to the upper surface of the airfoil, retards the "burbling" or breakdown of the flow, and hence permits larger values of the lift coefficient to be attained. The technicians of the Committee summarized the action of the front

[1] Daniel Guggenheim School of Aeronautics, New York University, New York, N. Y. Mem. A.S.M.E.

auxiliary airfoil as follows: "If the minimum gliding speed of the original airplane were 50 mph and the maximum speed in level flight 115 mph, the addition of the auxiliary airfoil in the optimum position would decrease the minimum speed to about 41 mph, and the maximum speed to 112 or 113 mph." It would appear, therefore, that the fixed auxiliary airfoil is a method of reducing landing speed without too great a sacrifice in top speed.

The fixed front airfoil is likely to prove particularly attractive to the airplane designer because it calls for no movable parts, and the practical airplane operator—or pilot—has a horror of what he terms "gadgets." On the other hand, it will not develop anything like the effectiveness (measured by the ratio of maximum lift coefficient to minimum drag coefficient) that some of the other devices have shown on test.

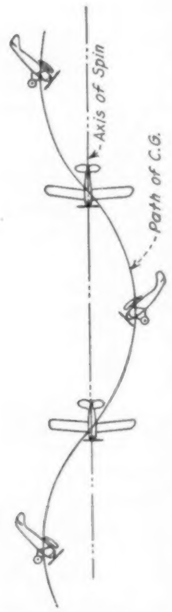


FIG. 1 PROTOTYPE SPIN

Thus the Handley Page slot and flap will give a higher maximum lift than the fixed auxiliary combination, and at the same time in neutral position should not affect the minimum drag. The other devices such as the Cunningham Hall high-lift wing, the Fowler variable wing area, etc., all have the disadvantage of comprising movable parts, but they give much higher maximum lift coefficients and also do not affect the minimum drag values of the airfoil.

The investigation of these lift-increasing devices has now passed the pure laboratory stage. By using any one of the above-mentioned devices the theoretical effectiveness of the wing can be increased and the speed range improved. Their advantages, therefore, are quite clear.

The practical difficulties are roughly as follows: (1) Added weight; (2) added expense; (3) the addition of movable mechanisms; (4) the fact that even if slow speed is obtained, we are not sure whether adequate lateral control can be maintained at very slow speeds; and (5) the fact that flaps and variable wing area move the center of pressure backward, and the diving moment thus produced must be counteracted in some fashion or other.

TAIL-SURFACE FLOW IN THE SPIN

In the prototype spin, as illustrated in Fig. 1, the airplane is on the whole descending vertically at a steady speed, V. At the same time it is revolving around the vertical axis at a steady angular speed. While the nose of the machine is pointing steeply downward, the air is striking the chord of the wing at a large angle, well beyond the stall or burble point. When once the airplane gets into this attitude of a steady spin, there are two principal reasons why the spin persists.

The first is that when an airfoil has gotten beyond the stall, it is capable of autorotation. In a normal attitude when an airplane rolls, the downgoing wing meets the air at a greater angle of incidence; this increases the lift on the downgoing wing. On the upgoing wing, the contrary is true. Hence the rolling motion about the chord as an axis is rapidly damped out. Beyond the stall that part of the wing which is going down meets the air at a greater angle of incidence, ***but loses lift thereby***. There we have the elementary explanation of autorotation. In the spin, the airfoil is working beyond the stall, in the autorotative region, and hence the spin tends to be maintained. Again, if we consider the centrifugal forces acting on the airplane due to its rotation about a substantially vertical axis, we can readily see that these centrifugal forces give rise to a couple that tends to raise the nose of the plane and thus to maintain the stalled condition of the airfoil.

In the spin, therefore, the action of the elevators is greatly impeded by the inertia or dynamic couple. The autorotative action of the airfoil helps to maintain the spin. The ailerons working well above the stall, cease to have much effectiveness. To stop the rotation, reliance must therefore be placed on the rudder and fin.

The experiments of British investigators show that, unfortunately, the rudder falls off in effectiveness because the flow past the rudder and fin is blanketed by the horizontal tail surfaces when the airplane as a whole is at a large angle of incidence.

It is probable that our designers will seek to depart from conventional tail-plane design: (1) the tail plane may be raised relatively to the rudder; (2) the horizontal tail surfaces be swept back so as to free the rudder and fin from interference; and (3) the rudder be so disposed as to have more of its area below the horizontal tail surfaces. The consensus of opinion seems to be that a rudder system operative in the spin can be obtained without radical departure from standard design, but with real attention to this matter of tail-surface blanketing.

MISCELLANEOUS AERODYNAMICS

The Committee is constantly extending our sum of aerodynamic data. A few typical investigations include that of the effect of thickness of an airfoil on the pitching moment at zero lift; tests for the optimum position of the propeller-engine nacelle combination with relation to the wing above or below which it is mounted; and the effect of the propeller on the landing speed of a tractor monoplane.

A NEW FUEL

The Standard Oil Company of New Jersey has developed an aircraft fuel with a flashpoint of over 117 F and an octane number or knock rating of 93.

At ordinary compression ratios of between 5 and 6, this new fuel develops the same brake mean effective pressure as ordinary domestic gasoline, but its fuel economy is less.

Ordinary domestic gasoline cannot be used at compression ratios above 6 without serious danger of knock or detonation. On the other hand, the new fuel can be employed without knock at compression ratios as high as 7.5. It then develops a higher brake mean effective pressure than the ordinary gasoline at a compression ratio of 5.3, and equals the ordinary gas in fuel economy.

It is quite clear, therefore, that while the new fuel is not so promising for operation with the aircraft engine precisely as it stands today, it should nevertheless have a very useful sphere of action with engines specially designed for higher compression ratios.

PROJECTED WORK WITH WIND TUNNEL AND MODEL BASIN

The large wind tunnel is at present devoted mainly to Army and Navy service problems, but the Committee will shortly undertake systematic research work in this laboratory. The model basin has already produced some valuable information. For example, it has been found that spray strips used on a flying-boat hull will increase the dynamic lift of the hull and diminish the hump resistance. In the model basin it is planned to undertake a systematic variation in the elements of hull and float design.

GRAPHICAL SYMBOLS FOR USE IN TWO ELECTRICAL FIELDS

Proposed American Tentative Standard Graphical Symbols for Electric Traction, Including Railway Signaling and Electric Power and Wiring

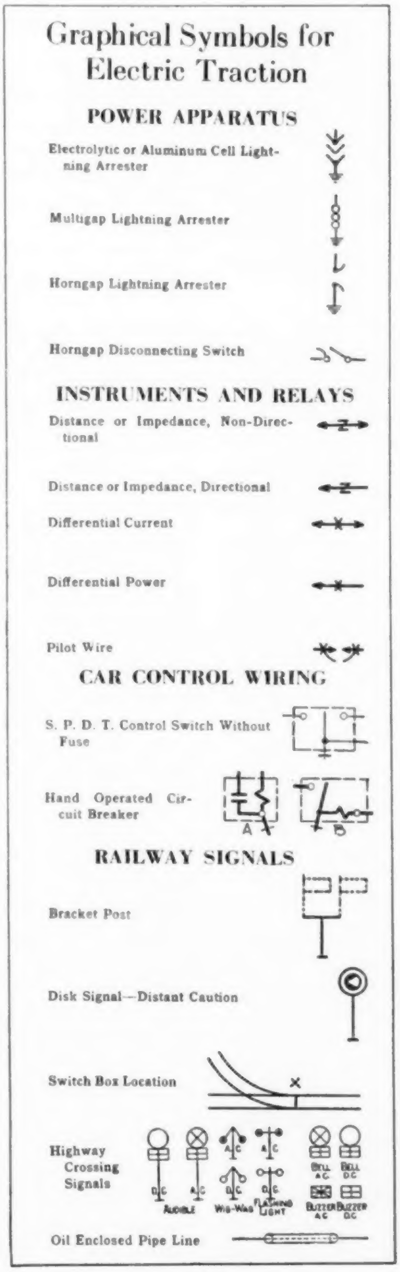
THE Graphical Symbols for Electric Traction, including Railway Signaling, proposed as an American Tentative Standard, are intended for use in the diagrammatic representation of apparatus usually encountered in the electric-traction field. They include symbols for equipment in power houses, substations, transmission and distribution systems, electrically operated cars and locomotives, and also electrical and associated equipment used in railway signaling.

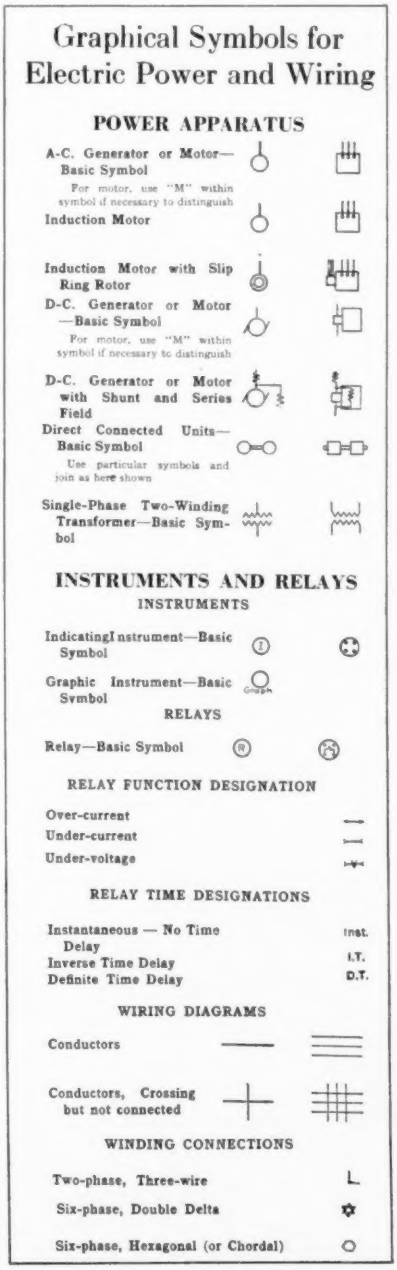
The proposed American Standard for Graphical Symbols for Electric Power and Wiring comprises graphical symbols applicable to one line, and complete diagrams of electric-power apparatus, instruments, and relays, and maps and connection diagrams. They are limited to apparatus usually encountered in electrical power engineering such as major electrical equipment in power houses, substations, and transmission and distribution systems. They do not, however, cover radio, communication, railway, or other allied branches of electrical engineering.

These two projects have been developed by Subgroups Nos. 5 and 2, respectively, of Subcommittee No. 7 on Electrotechnical Symbols, of which J. Franklin Meyer, Physicist, Bureau of Standards, Department of Commerce, Washington, D. C., is chairman. In compiling these two series of symbols, only those which have widespread practical use in industry have been included, and as far as possible the symbols covered by these two proposals have been harmonized with each other and with the symbols covered by other sections of the report, including that on radio symbols, developed by this same Subcommittee.

Included in the group of symbols developed by the Sectional Committee are Symbols for Mechanics, Hydraulics, Heat and Thermodynamics, Photometry, and Illumination, Aeronautical Symbols, Mathematical Symbols, Symbols for Electrical Quantities, Graphical Symbols for Radio and for Telephone and Telegraph Use, and Abbreviations for Scientific and Engineering Terms.

Portions of the two series of graphical symbols are published here for the information of readers before transmittal to the American Standards Association for designation as an American Tentative Standard. Communications in respect thereto should be sent to Subcommittee No. 7 in care of C. B. LePage, Asst. Sec., A.S.M.E., 29 West 39th St., New York, N. Y.





A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretation of the Committee in Cases Nos. 588 (Reopened), 712, 715, 721, 722, 723, as formulated at meeting of April 22, 1932, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE No. 588 (Reopened)

Inquiry: Will it be permissible in the forming of water legs in vertical tubular and firebox types of boilers, to attach the OG or flanged-in bottom edges of the plates by fusion welding? Case No. 313 permits of this construction for water legs of detached smokeless fireboxes, but the opinion of the Committee is requested in regard to this construction for water legs in boilers of these particular types.

Reply: Par. P-186 of the Code has been revised to provide for joints between the door-hole flanges of furnace and exterior sheets of boilers, provided these sheets are properly stayed or supported around the doorhole opening. It is the opinion of the Committee that where the load due to internal pressure on the plates forming the water leg is carried by staybolting and the inside width of the water leg does not exceed 4 in., the construction shown in Fig. 25, where both plates are flanged, will meet the requirements of the revised paragraph. The plates may be considered as fully supported if the distance from the weld to the nearest row of staybolts is not more than one-half the pitch allowed by the formula in Par. P-199.

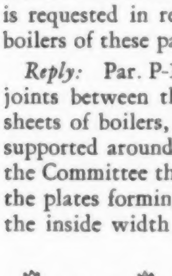


FIG. 25 (REVISED) METHODS OF FORMING WATERLEG JOINTS BY WELDING

CASE No. 712

Inquiry: Is it permissible, in the construction of welded steel-plate low-pressure heating boilers, to space staybolts a full pitch distance from a welded joint, or is this spacing limited to one-half of a full pitch?

Reply: It is the opinion of the Committee that welded joints as applied in the construction of steel-plate low-pressure heating boilers are for the purpose intended equivalent to riveted joints. The allowable distance from a corner welded joint to the nearest row of staybolts may be a full pitch as provided for in the formula in Par. H-21 of the Code for boilers to be operated at not to exceed 15 lb steam and 30 lb water. This does not apply to a welded joint in a flat surface, where the usual rules for staybolting are effective.

CASE No. 715

Inquiry: Will unfired pressure vessels fabricated by fusion welding under Class 2 test requirements meet the Code provisions if the base metal is a high-strength copper alloy of the following chemical and physical properties?

Copper	96	per cent (approx.)
Silicon	3	per cent (approx.)
Manganese	1	per cent (approx.)
Impurities, not over	0.5	per cent
Tensile strength, lb per sq in., min.	52,000	
Yield strength, lb per sq in., min.	18,000	
Elongation in 2 in., min	65	per cent
Reduction in area, min	70	per cent

The plate is hot rolled and annealed, and is free from injurious defects and flaws and has a workmanlike finish.

Reply: It is the opinion of the Committee that annealed copper-alloy plates or sheets having the chemical composition and minimum physical properties specified in the inquiry, may be used for the construction of unfired pressure vessels by fusion welding under the general requirements of Class 2 construction, the exceptions from which are that the elongation as determined by the free bend test shall not be less than 40 per cent, that the tensile strength shall not be less than that of the base metal, and that stress-relieving is not required for this kind of annealed material. The operation temperature shall not exceed 406 F. The maximum allowable unit working stress shall not exceed 9000 lb per sq in. for the material and $(S \times E) = 7200$ lb for joints welded as above specified.

CASE No. 721

Inquiry: Is it necessary, under the requirements of Par. P-302 of the Code, to use extra heavy valves on all steam outlets from a boiler when the pressure exceeds 125 lb per sq in.? Inquiry is also made as to the significance of the term "at least" in the first line of this paragraph.

Reply: The requirement for the extra heavy valves when the pressure exceeds 125 lb per sq in., applies to all outlet valves in the boiler. The term "at least" is intended to indicate that the design of all outlet valves should be sufficient to withstand the working pressure, which may in some cases require heavier construction than the standard extra heavy stop valves.

CASE No. 722

Inquiry: Can the word "close" as used in Par. P-314, where it is stated that feedwater shall not be discharged close to a riveted joint, be defined in terms of a definite distance?

Reply: It is the opinion of the Committee that it is not desirable to attempt to define the word "close" in terms of a definite distance. It is the intent of the Code that the feedwater shall not be discharged into a boiler so that it will flow directly against or along a riveted joint. If necessary, the discharge end of a feed pipe should be fitted with a baffle to divert the flow from the riveted joint.

CASE No. 723

Inquiry: Is it acceptable, under the rules of the Heating Boiler Section of the Code, to place wet-bottom steel-plate boilers closer to the floor line than the 12-in. clearance limit specified in Par. H-35?

Reply: It is the opinion of the Committee that for certain widths of the wet-bottom portion, the clearance above the floor line may be less than the 12 in. specified in Par. H-35, and it is therefore proposed to revise this paragraph to read:

> H-35. Boilers of the wet-bottom type having an external width of over 36 in. shall have not less than 12 in. between the bottom of the boiler and the floor line, with access for inspection. When the width is 36 in. or less, the distance between the bottom of the boiler and the floor line shall not be less than 6 in., and when any part of the wet bottom is not farther from an outer edge than 12 in., it shall not be less than 4 in.

Correspondence

CONTRIBUTIONS to the Correspondence Department of "Mechanical Engineering" are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Economic Lot Sizes

TO THE EDITOR:

The article by G. L. Studley entitled "Economic Lot Sizes" which appeared in the March issue of MECHANICAL ENGINEERING brings to mind another simplification of this subject by Paul N. Lehoczky which appeared in the August, 1928, issue of *Manufacturing Industries* (now *Factory and Industrial Management*).

The writer has found Mr. Lehoczky's treatment practical and wishes to pass it on to members who may have missed seeing it.

Briefly, it considers that the total cost of production per year on items which should obviously be manufactured in economic lots is the total of fixed annual charges (K), the total labor cost (L), the total set-up charges (XS), where X is the number of economic set-ups and S is the single set-up charge, and the interest on raw-material requirements (M/X), where M is the yearly interest charge. This gives an equation of the form

$$\text{Total yearly cost} = K + L + XS + M/X$$

Differentiating the equation with respect to X and finding the low point on the curve representing this equation by setting the resultant differential equal to zero, we secure a simple formula which lends itself to quick and easy calculations. Its form is

$$X = \sqrt{M/S}$$

The average production man need not know about these mathematical steps; all he need know is that he may use as a simple rule the relationship: The economic number of lots to manufacture during the year equals the square root of the yearly interest charges on raw-material requirements divided by the set-up charge per lot.

GEORGE G. BERGER.[1]

New York, N. Y.

[1] Consulting Industrial Engineer. Jun. A.S.M.E.

U. S. Navy Diesel-Engine Requirements

TO THE EDITOR:

Referring to Commander Gibson's paper on "U. S. Navy Diesel-Engine Requirements" in the December, 1931, issue of MECHANICAL ENGINEERING, some of the limitations which the author states have retarded the development of submarine oil engines in this country no longer exist. For instance, complicated steel castings with many small cross-sections are being largely replaced by combinations of simpler members, both with and without welded structural parts; through bolts and aluminum members constantly under stress, and other arrangements which avoid difficult manufacturing processes.

The United States Diesel-engine builders are well equipped, both technically and physically, to build light-weight, high-speed engines. The best in foreign design is available to them, perhaps even more so than to our Government departments. Consequently, our engineers may utilize overseas knowledge and experience in perfecting improved American engines.

Commander Gibson's paper leaves the impression that the two-cycle, double-acting engine is the type for surface ships. The writer heartily agrees with this as to vessels employing units of about 2000 hp each and larger, when headroom limitations or other local conditions do not dictate the simpler, more stocky, single-acting design. In the larger sizes the opposed-piston engine should be considered, as well as certain single-acting types which are by no means obsolete.

As to the smaller engines, both for surface and submarine services, the writer cannot agree that the four-cycle, single-acting will surely be the dominating type. At least three prominent European manufacturers are building two-cycle single-acting, high-speed engines on a commercial scale, and two or three such engines, of American design, are now being developed in this country.

There is being accumulated a substantial amount of data regarding locomotive, rail-car, bus, and aircraft oil engines, employing electric drive, gear drive, and direct drive, in this country, Great Britain, and Europe which will contribute greatly to the solution of these Navy problems by our engineers and manufacturers.

The writer's studies of the oil-engine situation, here and abroad for many years, and reviewed by an extensive European inspection trip in 1931, confirm his feeling that American engineers and American shops can produce American oil engines for the United States Navy which will be at least equal to any in any other Navy.

OLIVER F. ALLEN.[2]

New York, N. Y.

TO THE EDITOR:

Commander Gibson mentions the specialized training which the Navy Department is providing for those officers wishing to specialize in Diesel-engine work, and perhaps a slight amplification of this information may be of interest.

After usually from 4 to 6 years of service, subsequent to graduation from the Naval Academy at Annapolis, a small group wishing advanced work in this particular line is selected and returned to Annapolis for post-graduate instruction. The work there continues for about a year and a half and covers a thorough grounding in mathematics, electricity, thermodynamics, and metallurgy. After this, the group is sent to The Pennsylvania State College for a year and a half of graduate study along more highly specialized lines. This work is given

[2] Consulting Engineer, Mem. A.S.M.E.

under the supervision of the Mechanical Engineering Department, but comprises work in the Oil-Spray Laboratory and in the School of Mineral Industries, as well as in the Mechanical Engineering Department. Some research projects are undertaken, and each man is required to complete a thesis dealing with some individual project he has taken for investigation. It is a tribute to the far-sighted planning of the Navy Department that they have recognized the need of this specialization and are taking such steps to provide for it.

Consideration of the Diesel-electric drive where the generating plant consists of a number of Diesel-electric generating sets must take account of the disadvantage attendant on the multiplicity of these smaller units which seriously offsets the desirable feature of a reduction in power obtained by cutting out units, each operating at good efficiency. It is, however, at best but a rather indirect cure for the sacrifice of efficiency caused by the wide range of power required under operating conditions, and it seems reasonable to expect that the future will show that larger single units may be operated at reduced powers without grossly lessened efficiencies, and thus permit the retention of the smaller number of main power units.

H. A. EVERETT.[3]

State College, Pa.

TO THE EDITOR:

The general feeling in this country at the present time, referred to in Commander Gibson's paper, that the Navy Department has branded our Diesel-engine builders as incompetent to produce engines that will meet the requirements of the submarine service, does exist, and it is a real public service to clear the matter up.

It seems to the writer that the present bad situation would never have developed if the manufacturers equipped to build submarine engines had been willing to cooperate with the Navy in developing good engines. This lack of desire to cooperate forced the Navy into the engine-building business, and now we have a situation where the engine builders are willing and eager to build what the Navy wants, but the Navy appears to believe that it can get better results by designing and building its own eng nes.

When we study the engine requirements outlined by Commander Gibson we see that in some respects they are difficult. The operating conditions are severe. Maintenance is made more difficult by lack of room in this the most highly congested type of power plant in the world. Compared with the requirements of commercial work, however, the designer and builder have in some ways much more latitude in submarine-engine building. The commercial engine must not only be reliable, but its first cost and operating cost must be low or it cannot compete with steam. In the submarine engine reliability is paramount, and operating and first costs are comparatively unimportant. The Diesel has no competitor in this service. A somewhat similar condition exists in the air service. The airplane engine would not today be advanced anywhere nearly so much if the Army and Navy had not cooperated so closely with the engine builders in the days before the volume of commercial-airplane-engine business became large enough to stimulate development.

In the case of the purely submarine engine there can never be any sustaining commercial business. It is desirable, however, that engine building be turned over to commercial firms. There are constantly changing commercial developments that have a bearing on submarine-engine design, and with which the engine builders are in closer touch than the Navy Department.

LOUIS R. FORD.[4]

New York, N. Y.

TO THE EDITOR:

Even among the leading European Diesel builders, there is a wide divergence of opinion as to the ultimate design of Diesels for Navy surface ships. Commander Gibson, however, concludes that the trend is unmistakably toward the double-acting, two-cycle type for all Navy ships, from tanker to light cruiser.

The writer is of the contrary opinion, believing that up to 10,000-hp units, suitable for 40,000-shp quadruple-screw propulsion of battleships of the *Idaho* class, the single-acting, two-cycle, trunk-piston type will ultimately prevail, mainly because it is lower in height, more compact, far simpler, and is most favorable for the latest—and lightest—structural-welded construction. Adherence to a single school of thought is dangerous in planning a future Navy Diesel program, considering the pasent state of the art.

Lieut. J. O. Huse, one of the Navy officers sent abroad to obtain information on foreign Diesel development, clearly indicates that ultimate Diesel design has not yet crystallized, by his frank statement in *Diesel Power*, July, 1931:

> Trends in four-cycle Diesel designs must be carefully interpreted because the technique is changing so rapidly that the separation of experimental design from practical design is difficult. The industry is in a state of flux.

Dr. H. H. Blache, of Burmeister and Wain, in his paper, "The Present Position of the Diesel Engine for Marine Purposes," read before the Institute of Naval Architects, March 27, 1931, favors the single-acting, trunk-piston, 2-cycle Diesel for warships in the following statement:

> Diesel machinery will undoubtedly in the future be adopted for light cruisers operating long distances from their base. The new German cruiser *Ersatz Preussen* is the first of this type. The single-acting, two-stroke trunk engine is particularly suitable for this purpose, and Burmeister and Wain are at present constructing a small plant of this type of engine aggregating 2200 bhp for a single-screw passenger ship; but this is only a modest start, and engines of the same type can today be constructed up to 10,000 bhp per unit, the revolutions being about 350 per minute, and the weight, including thrust block, about 36 lb per bhp.

The views of Sulzer Bros. published at length in their *Technical Review*, 1928, following shop tests of their first double-acting, 2-cycle Diesel in 1927, favor the single acting, 2-cycle engine as opposed to the double-acting engine in sizes up to 10,000 bhp.

The comparative simplicity of the Doxford opposed-piston Diesel should entitle it to some consideration, at least for Navy tankers.

The 1931 figures will show a greater wave of popularity for the double-acting engine, especially the M.A.N. type, than is indicated by the foregoing figures. But hasty conclusions should not be drawn, as already a new commercial type of the simplest form of single-acting engine has been announced by Burmeister and Wain, by far the most extensive builders of marine Diesels, as "The Triumph of the Trunk-Piston Engine, Maximum Power in Minimum Headroom and Weight," with a 22,000-hp quadruple-screw installation already fitted in the

[3] Head, Department of Mechanical Engineering, The Pennsylvania State College. Mem. A.S.M.E.

[4] Consulting Engineer, Physics Building, Columbia University. Mem. A.S.M.E.

15,000-ton passenger liner *Reina del Pacifico* and a similar-type single-screw installation in the M.S. *Kalundborg*—both ships launched this year—and with similar installations in the 10,000-hp M.S. *Venus* and the *Ulster* ships.

America already holds leadership in the larger trunk-piston single-acting, two-cycle engine, predicted by Dr. Blache as the ultimate warship Diesel. In 1930, the Busch-Sulzer Bros. Diesel Engine Co. accepted an order to design and build a 3300-hp, 10-cylinder, trunk-piston, 2-cycle, airless-injection engine, the largest of this new type so far undertaken; and is now building, on order, a similar 2130-shp commercial marine unit. The weight of this type is about one-half that of the former crosshead, slower-speed, single-acting type, and, with airless injection, presents extreme simplicity in design and operation. It is prepared, with the full cooperation of the Navy, to undertake the design of special light-weight Diesels of this type in sizes up to 10,000 hp, and larger sizes in the double-acting type, under supporting orders that will justify the preliminary studies, research work, and development costs involved.

To clear up any misapprehension of the adequacy of American Diesel engineering that might be gained from statements in Commander Gibson's paper, the Busch-Sulzer Company has had its own staff of engineers specially trained in the calculation of critical torsional vibrations following the Sulzer method, which calculations have been made for all engine types for many years. To the neglect of its commercial business, its plant was placed exclusively at the disposal of the Government for the building of submarine engines during the war. The 72 Navy submarine Diesels it has built, from 300-hp to maximum rated 2500-hp units, were of its own design, not built under license, but with the advantages of technical collaboration with Sulzer Bros.

It would seem that the legislative authorization which the Bureau of Engineering seeks for its $3,000,000 experimental program to purchase, without competition abroad, special types of Navy Diesels, could be used to better advantage in paying qualified American builders to undertake the necessary development at home. The money spent would then advance the American Diesel industry, instead of providing further supporting orders for European competitive Diesel development. Such a change from the policy advocated by Commander Gibson would afford an American source of supply of future improved Diesels, especially in time of war—when it might be impossible to buy, again, later types abroad.

Edward B. Pollister.[5]

St. Louis, Mo.

The Balancing of Economic Forces

To the Editor:

I feel compelled to comment on the report of the committee of the American Engineering Council, published in the June issue of Mechanical Engineering to the effect that I believe it gives a correct analysis of economic conditions and offers many excellent ideas that could, ultimately, largely correct or adjust matters.

It seems to me, however, that there are two considerations quite apart from the report that block the way to any very immediate application of these ideas.

First, our government or political system is in the hands of those who can shout the loudest for the supposed benefit of their individual constituents; and, while I know the idea is not to have more government in business, nevertheless it seems that before much broad planning can be effected, our Congress must have a majority who have truly the idea of national welfare at heart, rather than local benefits or votes.

Second, it is not the idea of our engineering societies to take any active part in politics, and this is probably right, which leaves, as I see it, only the hope that over a period of years engineers can gradually influence others until the idea of Balancing Economic Forces can be sold to the nation.

The article on John Fitch and his troubles is a good illustration of what I think is the greatest difficulty, namely, to sell the idea or plan to the public.

Some expression of ideas on this point by the committee would be of great interest, I am certain.

James L. Haynes.[6]

Chicago, Ill.

Group Discussion of Economic Questions Advocated

To the Editor:

During the past few months a group of five gentlemen of diverse professions have been holding informal biweekly meetings to discuss ways and means of getting out of the present business depression, of avoiding similar situations in the future, and of generally informing themselves on the fundamentals of political economy.

These meetings have been fruitful of all sorts of ideas, some of more and some of less practical value. Among others has arisen one conviction which is the basis of the present suggestion. This conviction is that any good in the future must arise from the development of informed public opinion, aside from all questions of politics and party pressure. It is our feeling that such sentiment must be based on careful study by large numbers of well-informed citizens in order to be sound and permanent.

We suggest that, without formal organization, without constitutions, by-laws, dues, or regular meetings, there ought to be in this country 10,000 such groups as ours, meeting with a little more earnest effort than a chance luncheon visit, devoting an hour or an evening once a week or once a month to discussions and the cultivation of opinion on questions of business economics as affecting the country at large, banking policy, and regulation of the currency, a duty which the Constitution places in the hands of our elected representatives in Congress.

There are so many different opinions at present that it is difficult to see any hope for immediate concerted action. There are many plans offered to accomplish industrial stabilization. There are many interested and influential persons who intentionally oppose any form of stabilization. What do the American people want? The savings banks, life-insurance companies, and owned homes represent conservatively managed wealth in the hands of some forty million working persons. On the other hand, there are only thousands interested in speculation in the stock market, but they have influential voices in the formation of public opinion.

Which interest is of the greater importance to the American people? How shall a suitable and workable program be arrived at?

Ernest L. Robinson.[7]

Schenectady, N. Y.

[5] Busch-Sulzer Bros. Diesel Engine Co.

[6] Division Engineer, Hyatt Roller Bearing Co. Mem. A.S.M.E.

[7] Turbine Engineering Department, General Electric Co. Mem. A.S.M.E.

BOOK REVIEWS AND LIBRARY NOTES

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The Zuider Zee Reclamation Project

Wasserbauliche Modellversuche zur Klärung der Abflusserscheinungen beim Abschluss der Zuiderzee. (Model Research in Connection with the Zuider Zee Reclamation Project.) By Th. Rehbock. Rijksuitgeverij, The Hague, 1931. Cloth, $6^1/_2 \times 9^1/_4$ in., 282 pp., 57 photographs in text, 40 drawings on supp. plate, 5 florins.

Reviewed by William F. Durand[1]

THE great Zuider Zee reclamation project—the greatest hydraulic project of this character ever thus far undertaken—has given a splendid opportunity for the application of the laws of kinematic similitude to the study of the problems of water movement.

The engineering features of this great project were given in a British Association paper by J. W. Thierry published in *Engineering*, September 7, 1928, pages 305–308. The general plans contemplate a dam nearly twenty miles long across the northern end of the Zuider Zee, enclosing a total area of 915,000 acres, of which 550,000 will be reclaimed in three separate areas. Extending through the center and between these reclaimed areas will be left a fresh-water lake (Lake Yssel) for the discharge of the Yssel River through to the sea, and for the deposition of the sand and silt brought down by this stream. This lake will discharge its surplus water through a number of gate-controlled sluiceways in the dam into the so-called Wadden Zee, separated from the open water by a chain of islands. Around these reclaimed areas will be left a chain of channels and small lakes to serve as catch-water drains and at the same time as canals for water transport between the harbors along the present coast line. These must all be kept at the same level as Lake Yssel, and to this end must be provided also with sluiceways, locks, and gates.

These works thus involve, in particular, the construction of dikes, dams, sluiceways, locks, gates, and appurtenant structures, and it is these features of the project which have given the opportunity for the application of model study, carried out over a period of some nine years in the hydraulic laboratory of the Technische Hochschule at Karlsruhe, Germany, and under the direction of Dr. Th. Rehbock, director of the laboratory and author of the present report.

As the author says in his preface, these experiments and this undertaking have had for him, not only a high professional interest, but a peculiar personal interest as well, since his early years were spent in Amsterdam and circumstances have made him personally familiar from the first with the plans for this great project and with the problems which it presents.

The first series of experiments was carried out over the years from 1922 to 1926, and following the study of the results of these investigations a further series of check and control experiments was carried out during 1929–1930. The discussion and presentation of these extended series of researches entailed the preparation of more than one hundred graphical diagrams and charts with well over seven hundred photographic studies. In the present report no attempt is made to give these in complete detail, but rather to present a general account of the more important studies, with the principal conclusions to be drawn therefrom.

The investigations themselves have been grouped under two classes, those relating to the sluiceways, and those relating to the dam. In connection with both of these series of investigations, there have been carried out, not only the main laboratory-research programs on models of the structures as proposed, but also measurements on models of existing hydraulic structures, with measurements both full-scale and model, thus furnishing direct control over the conversion factors to be employed in passing from model to full scale.

No attempt can be made in the present review to give a detailed account of these matters, but to all interested in hydraulic work of this character and in particular in the application of model research to problems involving the flow of water, this report will be found of the very greatest interest and value. In particular, are to be found throughout the report most valuable indications for the carrying out of research of this character, with discussion of the underlying theory and indications of the precautions to be taken in carrying out such work and in applying the results to full-scale structures. The author, who is one of the great world authorities on research of this character and himself a pioneer in its development and application, is to be congratulated on having been able, in this way, to make a most noteworthy contribution to the literature of great engineering projects, and in particular as dealing with the application of model research to the study of the problems of fluid movements.

The Saga of Beryllium

Beryllium, Its Production and Application. Published by the Zentralstelle für Wissenschaftlich-Technische Forschungsarbeiten des Siemens-Konzerns. Translated by Richard Rimbach and A. J. Michel. The Chemical Catalog Company, Inc., New York, 1932. Cloth, 6×9 in., 331 pp., 198 figs., \$10.

THIS is a scientific book dealing with the metallurgy and industrial applications of a metal which only a few years ago was a laboratory curiosity, but it reads like a novel. The

[1] Stanford University, California. Past-President, A.S.M.E.

story is started by Prof. Alfred Stock, who says: "In December, 1919, Hans Goldschmidt, known to the world as the inventor of the thermit process, came to me with the question, 'Shall we do some research work together? I will bear the expense.' He realized that as a result of the destruction of so-called values caused by the inflation and aftermath of the World War, there was no safer investment than the creation of new knowledge."

"There is no safer investment than the creation of new knowledge" are words that could be fittingly written over every research undertaking.

Professor Stock accepted Goldschmidt's suggestion, and an extensive research program was laid out. The problem was a difficult one. It was necessary to effect the liquid separation of beryllium, the melting point of which is close to 1300 C, and no electrolysis had been carried out at such high temperatures before that time.

An electrolytic method of separation at 1300 C was ultimately worked out with the use of a water-cooled cathode. When it came, however, to reproducing the laboratory experiment on a commercial scale, outside assistance had to be sought, with the result that in the end the Siemens and Halske Company absorbed the research organization and continued the work.

The book comprises a series of articles prepared by various research men on such subjects as the occurrence of beryllium, its chemistry, production of beryllium and of its alloys, physical properties, and the effect of beryllium when alloyed with other materials.

The present review is limited to a consideration of the latter subject. In this connection it may be stated that beryllium-copper alloys containing 1.5 to 4 per cent of beryllium show a marked degree of age hardening, with a maximum hardness of about 400 Brinell. As a result of age hardening the tensile strength increases to about 213,000 lb per sq in., but there is a sharp drop in the elongation. Beryllium-copper alloy castings may also be age hardened. The electrical conductivity of heat-treated beryllium-copper alloys varies with the temperature of treatment, but there is no simple relation between the changes in conductivity and those in hardness. The modulus of elasticity during age hardening, even in the beginning of the process where the conductivity drops, undergoes the normal changes corresponding to the separation of the gamma crystals. On the basis of the observations of copper-beryllium alloys, age-hardening phenomena generally are discussed in conjunction with the precipitation of a second phase from the supersaturated solid solutions. A remarkable feature is that the addition of phosphorus accelerates the aging of beryllium-copper alloys and causes it to occur at lower temperatures.

The beryllium-nickel alloys have been only partly studied. The physical properties of the alloys containing 2 per cent and 2.5 per cent beryllium can be improved by quenching at 1000 to 1100 C and reheating to 400 to 450 C, whereby hardnesses up to about 600 kg per sq mm are attained.

The addition of nickel to beryllium steels has an unusually favorable effect in a number of ways. The ternary beryllium-nickel steels require only one-fourth the quantity of beryllium that is required for the binary beryllium steels for the same hardness. With an increasing nickel content the aging hardness changes in the following manner: With a nickel content ranging from about 4 to 23 per cent, a pronounced "hardness ridge" is obtained. With 23 per cent of nickel this "hardness ridge" breaks down and the much lower hardness values of the Invar steels are obtained. The latter requires a considerably higher quenching temperature to secure a greater aging effect.

Chrome-nickel beryllium steels have shown tensile strengths from 145,000 to as high as 258,700 lb per sq in.; in the latter case with an elongation of 3 per cent and reduction of area of 3 per cent. The steels with a tensile strength of 185,000 lb have shown an elongation of 7 per cent and a reduction of area as high as 52 per cent. As a general rule the physical properties of the beryllium steels correspond to the hardness numbers found.

The magnetic behavior of beryllium steels is peculiar. It is rather surprising to find that beryllium does not show any noteworthy physical properties as an alloying component in light-metal alloys, and that it is inferior to other metals which are alloyed with aluminum.—L. C.

Books Received in the Library

Analysis of Fuel, Gas, Water, and Lubricants. By S. W. Parr. Fourth edition, McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 8 in., 371 pp., illus., diagrams, charts, tables, $3. The title of this work represents the contents inadequately, for it contains, in addition to practical directions for analyzing the materials in question, a series of lectures upon them. These lectures, intended for students of mechanical engineering, are a valuable summary of the progress that has been made in fuel research and in knowledge of boiler waters and lubricants. The constitution and classification of coal, coal storage, coal contracts, carbonization methods, and the embrittlement of boiler plate are among the topics treated.

27 Berichtfolge des Kohlenstaubausschusses des Reichskohlenrates. V.D.I.-Verlag, Berlin, 1931. Paper, 8 × 12 in., 42 pp., illus., diagrams, charts, tables, 2.25 r.m. (new price). These reports continue the investigation of the fly-ash problem which is being carried on by the German National Coal Commission. The measurement of ash in flue gas and of the amount from lignite-fired boilers, American methods of ash collection, and the comparative costs of various methods of collection are discussed.

Bildwort Englisch, Technische Sprachhefte I—Power. V.D.I.-Verlag, Berlin, 1931. Paper, 6 × 8 in., 33 pp., diagrams, charts, 1.10 r.m. This interesting pamphlet is the first of a series for German engineers who wish to improve their knowledge of engineering English. The text consists of an essay in English describing the principal prime movers (heat engines and hydraulic turbines), accompanied by a number of clear drawings upon which the English name of each part is given. Some two hundred and fifty technical words are illustrated, and four hundred more are defined in a vocabulary. The method seems very practical.

Bildwort Englisch, Technische Sprachhefte, (2) Electricity, 1.35 r.m.; (3) Tools and Machine Tools, 1.15 r.m. V.D.I.-Verlag, Berlin, 1932. Paper, 6 × 8 in., 33 pp., diagrams, charts. The purpose of these interesting pamphlets is to assist the German engineer to acquire facility in reading engineering publications in the English language. Profuse use is made of machine drawings, with the names of each element clearly marked. The accompanying text introduces the words for abstract ideas. The method seems practical and might well be adopted for teaching German to Americans.

Die Elektrische Fernüberwachung und Fernbedienung für Starkstromanlagen und Kraftbetriebe. By M. Schleicher. J. Springer, Berlin, 1932. Cloth, 6 × 9 in., 238 pp., illus., diagrams, charts, tables, 21 r.m. Methods for the remote control and supervision of machinery and power are presented systematically in this work, one of the first to discuss the subject. Attention is directed to underlying principles and fields of usefulness rather than to the details of the instruments. Remote metering, signaling, and control are considered. A useful bibliography is included.

Davison's Silk and Rayon Trades. Thirty-seventh edition, pocket edition. Davison Publishing Co., New York, 1932. Cloth, 5 × 7 in., 626 pp., illus., maps, $5. This directory includes all the information usually needed by those engaged in the trade as manufacturers of yarns and fabrics, dealers, etc. The capacity, location, products, and officers of all manufacturers are given, together with lists of agents, jobbers, dyers, and finishers.

Dynamics of Engine and Shaft. By R. E. Root. John Wiley & Sons, New York, 1932. Cloth, 6 × 9 in., 184 pp., illus., diagrams,

charts, tables, $3. For twelve years Professor Root has given a course at the Postgraduate School, Naval Academy, upon this subject, and the results of his experience appear in this brief textbook. It aims to present methods for evaluating the forces that operate in a reciprocating engine, to trace their effects in turning moment on the shaft and in bearing pressures, and to reveal their significance in relation to vibrations. The book also treats of torsional and transverse vibrations of elastic systems and discusses critical speeds.

ECONOMICS OF TOOL ENGINEERING, JIG AND FIXTURE DESIGN. By A. P. Gwiazdowski and C. B. Lord. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 203 pp., illus., diagrams, charts, tables, $2.50. Intended as a textbook for engineering students with previous practice in pattern-making, founding, forge work, and machine-shop work, this work is an introduction to the subject which will also be useful to toolmakers and draftsmen. Tooling methods in general are discussed, as well as those used in various industries. The available methods of producing machine parts, cutting tools, drilling, milling, and the design of jigs and fixtures are treated.

ENGRAVING AND PRINTING METHODS. By C. J. Hayes. Scranton, Pa., International Textbook Co., 1930. Cloth, 5 × 8 in., 84 pp., illus., diagrams, charts, $3. This manual is intended to give those preparing advertising matter a knowledge of methods of printing and illustrating which will enable them to select the processes best suited to the purpose and to judge the quality of the results. Special attention is given to illustration.

ESTIMATING FOR MECHANICAL ENGINEERS. By L. E. Bunnett. Isaac Pitman & Sons, New York and London, 1932. Cloth, 6 × 9 in., 168 pp., diagrams, charts, tables, $3. This volume discusses such subjects as labor costs, materials, speeds, feeds, labor of various kinds, fixed charges, and the manner in which complete estimates are built up. Much scattered information of value to the estimator is brought together, with advice on pitfalls to be avoided.

FARM GAS ENGINES AND TRACTORS. By F. R. Jones. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 8 in., 485 pp., illus., diagrams, charts, tables, $3.75. Treats of the construction, operation, application, and use of these machines. The style is simple and concise, and the treatment is practical and sufficiently comprehensive to meet all ordinary needs of the owner and operator.

GENERAL ENGINEERING HANDBOOK. Edited by C. E. O'Rourke and others. McGraw-Hill Book Co., New York, 1932. Leather, 5 × 8 in., 921 pp., diagrams, charts, tables, $4. In preparing this compendium of engineering data, the compilers have attempted to compress the important fundamentals of the various branches of engineering into a single small volume which will supplement any of the detailed handbooks devoted to one of them. The work is divided into thirty-one sections, six of which are devoted to subjects of interest to all engineers, mathematics, weights and measures, materials, mechanics, hydraulics, and graphic statics. The remainder treat the major branches of civil, mechanical, and electrical engineering. Each section is prepared by an expert in its field.

The selection and arrangement of the material has been done with great skill, and the amount of practical, frequently needed information presented is remarkable. The book should be very useful to most engineers, particularly as a convenient source of information upon subjects which lie outside their usual field of work.

HANDBOOK OF BUSINESS ADMINISTRATION. W. J. Donald, ed. McGraw-Hill Book Co., New York and London, 1931. Leather, 5 × 7 in., 1753 pp., diagrams, charts, tables, $7. This is an encyclopediac presentation of current practice in all departments of business, prepared by a group of specialists and sponsored by the American Management Association. Marketing, financial management, production management, office management, personnel management, and general management are discussed in all their ramifications. The book is a concise, handy summary of the policies followed by many business leaders.

HEAVY-OIL ENGINES OF AKROYD TYPE. By W. Robinson. Blackie & Son, Ltd., London & Glasgow, 1931. Cloth, 6 × 9 in., 142 pp., illus., diagrams, charts, tables, 7s. 6d. Beginning with an account of Herbert Akroyd Stuart's experimental work, this book traces the development of the modern compression-ignition oil engine and describes its applications to marine and airship propulsion, railway traction, and electric power plants. The author feels that Stuart has not received the recognition that his inventions deserve.

THIRD INTERNATIONAL CONFERENCE ON BITUMINOUS COAL, November 16–21, 1931. Proceedings, 2 vols. Carnegie Institute of Technology, Pittsburgh, 1932. Cloth, 6 × 9 in., Vol. 1, 965 pp.; Vol. 2, 1034 pp.; illus., diagrams, charts, tables, $15. The subjects discussed at this conference include the economic problems of the coal industry, the competition between fuels, low-temperature and high-temperature carbonization, problems of carbonization, gasification by-products, hydrogenation, liquefaction, railroad, steamship, domestic and power-plant fuel, pulverized fuel, smoke and dust abatement, preparation, cleaning, origin and classification of coal, and the disposal of mine drainage. Upon each of these subjects a number of papers were presented by American and European authorities of high rank, and these volumes afford an interesting picture of present conditions and trends in this field.

INTERNATIONAL CONGRESS FOR GENERAL MECHANICS, Liége, 31 August–5 September, 1930. Three vols. Institut de Mécanique, Liége; Dunod, Paris, 1931. Paper, 9 × 12 in.; vol. 1, 292 pp.; vol. 2, 364 pp.; vol. 3, 274 pp.; illus., diagrams, charts, tables, 350 Belgian francs. This congress was held to discuss questions of interest to designers and builders of machinery, to review recent work in that field, and to study new fields for research. The subjects considered included steam and internal-combustion engines, hydraulic turbines, steam boilers and condensers, transmissions, machine tools, conveyors, and recording instruments. A large number of valuable papers on these and related topics are included in this record.

LÄRM UND RESONANZSCHWINGUNGEN IM KRAFTWERKSBETRIEB INFOLGE PERIODISCHER STRÖMUNGSVORGÄNGE. By F. Michel. V.D.I.-Verlag, Berlin, 1932. Paper, 6 × 8 in., 84 pp., illus., diagrams, charts, tables, 7.50 r.m. An investigation of the sources of the causes of noise and resonant vibrations in boiler plants and water-power plants. Such effects as the rumbling of boilers, the whistling of pipes, the noises of fans and air pipes, water hammer, and vibrations of high-tension conductors are discussed, and methods for preventing or ameliorating them are indicated.

LUFTBEHANDLUNG IN INDUSTRIE- UND GEWERBEBETRIEBEN. By L. Silberberg. J. Springer, Berlin, 1932. Cloth, 6 × 10 in., 174 pp., illus., diagrams, charts, tables, 18 r.m. This treatise on air conditioning is intended to provide an account of current practice, for engineers and factory owners. After an introductory section devoted to the scientific principles, the technique of air conditioning is discussed at some length. The problems involved, the methods of solving them, and the apparatus used are considered. Advice on the choice of systems and operating costs is given.

MANUAL OF ELECTRIC ARC WELDING. By E. H. Hubert, editor. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 163 pp., illus., diagrams, tables, $2. This book explains the fundamentals of arc-welding processes, gives practical suggestions for performing various welding operations and enumerates many uses of arc welding. The directions are clear and full, and the book presents the main facts that welders and engineers need to know. The publication is sponsored by the Welding section of the National Electrical Manufacturers Association.

MARLBOROUGH'S GERMAN TECHNICAL WORDS AND PHRASES, English-German and German-English Dictionary. Third edition, enlarged and revised by E. M. Rolffs. E. Marlborough & Co., London, 1931. Paper, 6 × 9 in., 188 pp., 7s. 6d. Contains well-selected English-German and German-English vocabularies of terms used in engineering, building, music, medicine, and other arts and trades. The book is clearly printed, convenient in size, and should be useful to those seeking an inexpensive general technical dictionary.

OIL ECONOMICS. By C. Osborn. McGraw-Hill Book Co., New York and London, 1932. Cloth, 6 × 9 in., 402 pp., illus., diagrams, charts, maps, tables, $4. A comprehensive analysis of the oil business from the economic point of view. The book is intended to give oil men and investors a brief review of the main economic facts about oil, and a concise, useful explanation of the methods by which price movements and profits are analyzed and forecast.

DIE PUMPEN. By H. Matthiessen and E. Fuchslocher. Third edition. J. Springer, Berlin, 1932. Paper, 6 × 9 in., 106 pp., illus., diagrams, charts, tables, 3.30 r.m. A concise textbook on the design and construction of reciprocating and rotary pumps. The necessary calculations are given in full and the construction of the various parts covered carefully. The book is well fitted to the usual needs of students.

CURRENT MECHANICAL ENGINEERING LITERATURE

Selected References From The Engineering Index Service

(The Engineering Index Service Is Registered in the United States, Great Britain, and Canada by the A.S.M.E.)

THE ENGINEERING INDEX SERVICE furnishes to its subscribers a Weekly Card Index of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Of the many items of particular interest to mechanical engineers a few are selected for presentation each month in this section of "Mechanical Engineering." In operating The Engineering Index Service, The American Society of Mechanical Engineers makes available the information contained in the more than 1800 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession. At the end of the year all references issued by the Service are published in book form, this annual volume being known as "The Engineering Index."

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

AIR COMPRESSORS

CENTRIFUGAL. Centrifugal Compressors, W. J. McBride. Gen Elec Rev v 35 n 5 May 1932 p 248–55. General description; theoretical considerations; compression of air; compression of gases; multi-stage compression; compression without cooling; characteristic curves.

FLOW AROUND VALVES. Stroemungsvorgaenge und Bewegungsverhaeltnisse bei Druckventilen schnellaufender Kompressoren, E. Lanzendoerfer. VDI Zeit v 76 n 14 Apr 2 1932 p 341–5. Investigation of flow phenomena around valves of high-speed reciprocating compressor; differences in flow for continuous and pulsating air currents; graphs illustrate effects of various operating conditions on valve action.

TURBO-COMPRESSORS. Control of Turbine Compressors Applied to Bessemer Converters, A. P. Mansfield. Blast Furnace and Steel Plant v 20 n 3 Mar 1932 p 259–61. Use of individual steam-turbine-driven centrifugal air compressors at McKeesport, Pa; each compressor is three-stage unit with capacity of 38,000 cu ft per min, and when delivering air at 30 lb pressure, operates at approximately 4800 rpm; operation of governing mechanism with remote control.

AIRPLANE ENGINES

DIESEL. Technical Description of Guiberson Diesel Engine. Aviation Eng v 6 n 4 Apr 1932 p 19–21. Design and performance data of 9-cyl 4-cycle air-cooled radial engine of $4^{13}/_{16}$ by 6 in. bore and stroke, developing 185 hp at 1925 rpm; decompression enables "free wheeling" in flight; weight, 510 lb; fuel consumption cruising, $8^1/_2$ gal per hr.

AIRPLANES

CATAPULTS. Catapult for Launching Aeroplanes. Engineering v 133 n 3457 and 3458 Apr 15 1932 p 447–9 and Apr 22 p 479–90 2 supp plates. Apr 15: Catapult built by MacTaggart, Scott and Co; designed to launch aircraft up to 8000 lb in weight at speed of 57 mph, though lighter machines can be launched at higher speeds; longitudinal movement in either direction of extending portions is effected by means of electrically driven winch. Apr 22: Means provided for accelerating and retarding trolley.

LOAD FACTORS. Rational Specification of Airplane Load Factors, E. P. Warner. Soc. Automotive Engrs J v 30 n 4 Apr 1932 p 171–8. For four conditions of flight, formulas for calculation of wing load factors and charts are given; true factors of safety suggested for different flight conditions; except for airplanes of less than 6000 lb weight or those having balanced elevator controls, weight of airplane is minor element in determining load factors; power loading first in importance for big airplanes.

METAL-CONSTRUCTION. British Development of All-Metal Aircraft, J. G. Fairlie. Military Eng v 24 n 134 Mar–Apr 1932 p 161–6. Strength properties and design of typical spars, struts, and ribs; comparison of properties of duralumin and steel strip; data on heat treatment.

PERFORMANCE CALCULATION. General Formulas and Charts for Calculation of Airplane Performance, W. B. Oswald. Nat Advisory Committee Aeronautics—Report n 408 1932 50 p. Development of formulas for determination of major airplane performance characteristics making no assumption regarding attitude of airplane at which maximum rate of climb occurs, but finding attitude at which excess thrust horsepower is maximum; performance in terms of parasite loading, effective span loading and thrust horsepower loading.

Mutual Action of Airplane Body and Power Plant, M. Schrenk. Nat Advisory Committee Aeronautics—Tech Memo n 665 Apr 1932 35 p 10 supp plates. Development of general propeller performance and rpm curves which, combined with general curve of power required for level flight, present complete picture of performance; adjustable-blade propeller and supercharged engine. Translated from Zeit fuer Flugtechnik und Motorluftschiffahrt Dec 14 and 28 1931.

Vereinfachtes Verfahren zur Berechnung der. Flugleistungen von Landflugzeugen, G. Foerstner. Zeit fuer Flugtechnik und Motorluftschiffahrt v 23 n 6 Mar 29 1932 p 169–73. Simplified procedure for calculating performance of landplanes based on formulas developed by H. Blenk; use of nomograms and standardized blanks.

WINGS. Flugzeuggroesse und Dickenverhaeltnis des Fluegelwurzelprofiles, C. Toepfer. Zeit fuer Flugtechnik und Motorluftschiffahrt v 23 n 6 Mar 29 1932 p 165–7. Relations between airplane size and thickness ratio of wing profile with particular reference to transoceanic seaplane designed by Rumpler.

ALLOY STEELS

CORROSION-RESISTING. Les aciers chimiquement resistants dits "inoxydables," A. Portevin. Revue Universelle des Mines v 7 n 4 Feb 15 1932 p 198–223. Chemically resistant steels and their industrial importance; rules relating to corrosion of alloys and metals; application to steels; acid-resisting chromium and other alloy steels, cast iron and ferroalloys; manufacture of stainless chromium steels; cold working, forging, and rolling; heat treatment; metallographic control.

ALLOYS

BEARING METALS. See *Bearing Metals.*

AMMONIA CONDENSERS

DESIGN. Modern Ammonia Condenser Design, W. R. Kitzmiller. Power v 75 n 16 Apr 19 1932 p 592–4. Efficiency of refrigerating plant can be greatly affected by performance of ammonia condenser, and its design and selection should be given careful consideration; advantages of several types of shell-and-tube condensers; heat removed from condenser; dimensions of condensers in common use; comparison of initial cost.

ASH HANDLING

ARRANGEMENT OF EQUIPMENT. Coal and Ash Handling. Nat Elec Light Assn—Publ n 210 Apr 1932 5 p. Radical departure in matter of location and arrangement of coal-storage and handling equipment; analysis of central-station methods of coal weighing emphasizes necessity of cleanliness, regular and thorough inspection, and frequent testing, if desired accuracies are to be maintained.

AUTOMATIC CONTROL

THRUSTORS. Diversity of Applications for Thrustors, R. F. Emerson and S. A. Holme. Gen Elec Rev v 35 n 5 May 1932 p 267–70. Device consists of three main elements: cylinder containing oil, piston, and small motor driving impeller immersed in oil; when motor is energized, impeller creates pressure in oil, causing piston to rise as oil passes from above piston to chamber beneath; thrustor finds application in many fields, such as steel mills, laundries, bakeries, machine shops, mines, material handling, etc.

AUTOMOBILE ENGINES

CONNECTING RODS. Cadillac Connecting Rods Made by New Forging Process, L. A. Danse. Iron Age v 129 n 15 Apr 14 1932 p 869–71. Outline of entire process of manufacturing rods, including their heat treatment and special measuring instruments used to test quality and accuracy of work.

CYLINDERS. Making Cylinder Liners. Automobile Engr v 22 n 292 Apr 1932 p 169–74. Production methods and equipment of Sheepbridge Stokes Centrifugal Casting Co., Chesterfield, where centrifugal casting process is applied to manufacture in large quantities; composition and wear resistance of cast-iron and nitrided cast-iron liners.

AUTOMOBILES

AIR RESISTANCE. Drag of Cars Charted in Wind Tunnel Tests, W. E. Lay. Automotive Industries v 66 n 14 Apr 2 1932 p 520–2. Investigation of aerodynamic characteristics of simple body forms in wind tunnel of Department of Aeronautical Engineering, University of Michigan; graphs illustrate values of air-resistance coefficient as affected by shape of front and rear end.

SHOCK ABSORBERS. Automatic Shock-Absorber, W. S. James and F. E. Ullery. Soc. Automotive Engrs J v 30 n 5 May 1932 p 185–9 (discussion) 189–91. Analysis with aid of indicator cards made on machine shown in diagrammatic drawing; effects of incorrect design of valves and of dirt in oil passages; effect of change in viscosity of working fluid; operating principles of orifice-control valve with thermostatic element

which has given satisfactory results in laboratory and on road.

STEEL FOR. Manufacture and Heat Treatment of Sheet and Strip Steels, E. F. Davis. Fuels and Furnaces v 10 n 4 Apr 1932 p 261–4. Bright annealing of sheet and strip steel; different gaseous atmospheres used; types of furnaces used in this process; cold rolling of sheet and strip steel.

TRANSMISSIONS. Neuerungen an Schaltgetrieben fuer Kraftfahrzeuge, A. von Soden. Automobiletechnische Zeit v 35 n 5 and 6 Mar 10 1932 p 120–3 and Mar 25 p 155–61. Survey of recent developments in design of European and American transmissions, including overdrive, silent gears, free wheeling, etc.; sketches illustrate features of representative makes; operating principles of Maybach and Mercedes-Benz preselective gear-shifting mechanisms.

AUTOMOTIVE FUELS

CRITERIA OF. Criteria of Modern Fuels, L. G. M. Roberts. Petroleum Times v 27 n 682 Feb 6 1932 p 141–2. Effects of anti-knock efficiency, volatility, and stability of principal types of fuels on design and operation of internal-combustion engines; quality of Diesel-engine fuels determined by composition, distillation range, viscosity (and lag time), sulphur, flash point, and spontaneous-ignition temperature, and ash, coke, and water content, as well as asphalt. Before Instn Automobile Engrs.

BEARING METALS

BRONZE. Contribution à l'étude de l'influence du nickel sur les propriétés des bronzes au plomb, J. Dessent. Revue Universelle des Mines v 7 n 3 Feb 1 1932 p 99–102. Contribution to study of influence of nickel on properties of leaded bronzes used in bearings; results show addition of about 2 per cent nickel is advantageous.

BEARINGS

DESIGN. Das wirtschaftliche Hochleistungs-Gleitlager, E. Falz. Ingenieur v 47 n 15 Apr 8 1932 p 29–39 and (discussion) 39–44. Principles of bearing design and performance; factors controlling bearing pressure, location of oil groove, and friction losses; machining and mounting.

LUBRICATION. Experimental Determination of Distribution and Thickness of Oil Film in Flooded Cylindrical Bearing, J. Goodman. Instn Civ Engrs—Min Proc v 23 n 4826 1932 25 p 3 supp plates. Interpretation of results obtained from 90-deg bearing with small clearance; representation of relations between speed, bearing pressure, viscosity, clearance, temperature of film, coefficient of friction, eccentricity ratio, and end leakage of oil.

Film Lubrication of Journals, J. C. Brierley. Engineer v 153 n 3981 Apr 29 1932 p 477–8. Editorial comment on paper before Institution of Mechanical Engineers; it seems certain that employment of film lubrication in cylindrical bearings will be limited to relatively few special cases.

Hydrodynamische theorie van de kussenbloksmering, F. K. T. van Iterson. Ingenieur v 47 n 15 Apr 8 1932 p 44–8. Résumé of hydrodynamic theory of bearing lubrication, with special reference to Michell bearing and fluid-film lubrication.

Possible Criterion for Bearing-Temperature Stresses, D. P. Barnard. Soc Automotive Engrs J v 30 n 5 May 1932 p 192–4 and (discussion) 194–7. Application of criterion consisting of product of oil viscosity by square of running speed considered on heat-balance basis and compared with series of observations of crankcase temperatures in number of typical cars.

Stability of Lubricating Films in Journal Bearings, H. W. Swift. Instn Civ Engrs—Min Proc v 23 n 4809 1932 24 p. Mathematical analysis of design factors controlling stability of oil films; calculation of pressure distribution in partial bearings and comparison with observation.

NOMY TYPE. Teoretisk och Experimentell Analys av Nomy-Lagret, F. Odqvist. Teknisk Tidskrift v 62 n 8 Feb 20 1932 (Mekanik) p 17–25 supp plate. Theoretical and experimental analysis of Nomy bearings with particular regard to solution of lubricating problems; methods of determining oil-film thickness.

OIL SEAL FOR. Self-Contained Oil Seal for Bearings. Engineering v 133 n 3458 Apr 22 1932 p 502. Single seal introduced by Charles Weston, known as Gits precision oil seal, is standardized for shafts ranging in diam from $^5/_{16}$ in. to 6 in.; consists essentially of special form of self-contained unit.

BELT DRIVE

LEWIS EFFECT. Action de la pesanteur sur les courroies. Effet Lewis, R. Swyngedauw. Société d'Encouragement pour l'Industrie Nationale—Bul v 131 n 3 Mar 1932 p 197–216. Experimental and mathematical investigation of influence of weight on belt, with particular regard to Lewis effect; graphical determination of Lewis effect on basis of elastic properties and specific weight of belt and of dimensions of drive.

BINARY-VAPOR SYSTEM

PRESENT STATUS. Where Binary Cycle Stands Today, P. W. Swain. Chem & Met Eng v 39 n 4 Apr 1932 p 204–5. It is claimed that system holds real promise for process industries, but must compete with high steam pressures; simplified hook-up of mercury-vapor-steam plant supplying process steam for manufacturing; model of mercury-vapor plant under construction at Schenectady; combined high- and low-pressure steam plant.

BLOWERS

MODERN TYPES. L'utilité de l'aération et les procédés modernes de ventilation, C. Coupard. Technique Moderne v 24 n 8 Apr 15 1932 p 231–6. Design and construction of various types of ventilating blowers and fans, including Chanard and Coupard systems; mine ventilating.

BOILER FURNACES

COOLING. Der Aufbau von Feuerraumrohrwaenden, Harraeus. Feuerungstechnik v 20 n 2 Feb 15 1932 p 18–21. Construction of furnace tube walls; types and arrangements of tube walls; cooling tubes; various cooling agents for tube wall; connection of cooling system and boiler.

Vor- und Nachteile der Feuerraumkuehlung, H. Schlicke. Brennstoff und Waermewirtschaft v 14 n 3 Mar 1932 p 41–3. Advantages and disadvantages of furnace cooling; claimed to be most reliable means of protecting furnace walls and grate; installation in existing plant lowered steam temperature in superheater; operating difficulties.

RADIATION. Waermeuebertragung durch Strahlung im Feuerraum, H. Friedrich. Mitteilungen aus den Forschungsanstalten v 1 n 10 Mar 1932 p 227–43. Heat transfer by radiation in furnace; theoretical principles; tests on MAN sectional boiler of 13 abs atm pressure with heating surface of 350 sq m; measurements of flue-gas temperature; instruments employed; losses in combustion chamber; heat radiation in furnace through grate and masonry; gas radiation.

BOILERS

AUTOMATIC CONTROL. Leistungssteigerung in einem Elektrizitaetswerk mit teilweiser Bahn- und Pendellast durch vollautomatische Feuerfuehrungsregler, Heinig. Brennstoff- und Waermewirtschaft v 14 n 1 Jan 1931 p 1–6. Full automatic remote control of boiler installation led to important economic improvements showing considerable savings in fuel; factors which have led to improvement; design details of control equipment, operating results, and diagrams are given.

Thyratrons and Selsyns Control High-Pressure Steam Generator, A. A. Potter, H. L. Solberg, and G. A. Hawkins. Power v 75 n 16 Apr 19 1932 p 584–8. Series steam generator with any desired pressure up to 3500 lb per sq in. and at max temperature of 830 F equipped with automatic combustion control in which thyratron tubes are source of power for elements regulating supply of fuel, air, and water; mechanism for actuating control operated through Selsyn sending and receiving units.

DESIGN. Pressure-Furnace Boiler Is Revolutionary Development. Power v 75 n 15 Apr 12 1932 p 562–4. Brown-Boveri develops Velox boiler, whose furnace operates under several atmospheres pressure; may operate on explosion cycle or constant-pressure cycle; planned for use with steam- and gas-turbine installations; plant outputs of 30 kw to 40 kw per cu ft of furnace space are claimed; gas-turbine cycles; section through small Velox steam generator.

ELECTRIC. Electric Steam Generator Supplies Peak Loads, M. G. Sanders. Power v 75 n 17 Apr 26 1932 p 624–5. Details of equipment and methods employed by Aluminum Co. of Canada for steam supply during peak loads; characteristics of electric steam generator of Kaelin type; feed-water storage.

HIGH-PRESSURE. Les métaux utilisés dans la construction des appareils à vapeur à haute pression et à température élevée, J. Galibourg. Technique Moderne v 24 n 8 Apr 15 1932 p 225–31. Results of testing and heat treatment of steel and alloys used in construction of high-pressure, high-temperature steam boilers and equipment.

MARINE. Velox Explosion Boiler. Mar Engr and Motorship Bldr v 55 n 655 Apr 1932 p 125–7. New Brown-Boveri Velox boiler is steam generator with pressure-charged combustion chamber; large saving of weight and space is claimed.

RIVETED JOINTS. Kraftfluss in Laschenverbindungen, Ebel and Reinhard. Waerme v 55 n 14/15 Apr 9 1932 p 221–32. Investigation of flow of force in butt joints; elongation conditions were examined on special rubber models; it is shown that, even without influence of riveting process, static maximum load is in proportion to contact surface of plate; results of experimental tests on rubber model were successfully applied to iron riveted joints.

SLUDGE REMOVAL. Der Kesselschlamm, ein bisher unerkannter Gefahrenher, H. Richter. Chemiker-Ztg v 56 n 18 and 20 Mar 2 1932 p 173–4 and Mar 9 p 195. Boiler sludge, hitherto unknown source of danger; cause of sludge is closely related to that of boiler scale; feedwater treatment; injurious effects of sludge, means of removal.

TUBULAR. Der Sektionalkessel, Bauart Jiges. W. Gumz. Feuerungstechnik v 20 n 3 Mar 15 1932 p 42–5. Jiges sectional boiler, new type of high-capacity boiler, patented by J. G. Sandwall, Helsingborg, Sweden; sections consist of rectangular tubes arranged horizontally.

WATER-TUBE. Die Strahlung des Rostes in einem Wasserrohrkessel, R. W. Meuller. Feuerungstechnik v 20 n 3 Mar 15 1932 p 37–42. Radiation of furnace in water-tube boiler; advance from empirical field to scientific treatment of heat problem; review of previous studies of heat radiation; calculating methods of Sulzer Bros; heat radiation of grate; determination of angle conditions; example of calculation and conclusions.

Neuere Arbeiten ueber den Wasserumlauf in Wasserrohrkesseln, R. Boese. Archiv fuer Waermewirtschaft v 13 n 4 Apr 1932 p 89–92 (discussion) 92. Recent studies of water circulation in water-tube boilers; comparison of methods developed by Muenzinger, Schmidt, Schultes, and Seidel for determining velocity of water flow into vertical tube with aid of tests by Cleve.

CABLEWAYS

FRANCE. Le funiculaire aerien a voyageurs de l'usine électrique d'Artouste (Basses-Pyrénées.) Génie Civil v 52 n 13 Mar 26 1932 p 308–14. Description of patented cableways at Artouste hydroelectric plant, in department of Basses-Pyrénées, having total length of 1053.5 m and rise of 783 m; details of mechanical equipment.

CAMS

DESIGN. Zur Bestimmung der Geschwindigkeiten und Beschleunigungen von Ventilen raschlaufender Verbrennungskraftmaschinen, K. Schlaefke. Mitteilungen aus den Forschungsanstalten n 9 Jan 1932 p 219–24. Kinematic analysis of different cam shapes for determining speed and acceleration of valves of high-speed internal-combustion engines.

CARBURETORS

ATMOS. Der Atmos-Vergaser, W. Ostwald. Allgemeine Automobil-Ztg v 33 n 14 Apr 2 1932 p 15–17. Operating principles and performance tests of carburetor with special atomizing design developed by Atmosvergaser A.-G.

CARS, DUMP

AUTOMATIC. Self-Propelled and Operated Dump Car. Mech Handling v 19 n 4 Apr 1932 p 121–2. Construction and operation of self-propelled and operated dump car, in which all essential features of straight locomotive and separate dump car are combined in one unit; dimensional details; characteristics of propulsion unit.

CARS, FREIGHT

DESIGN. High-Speed Freight-Car Trucks Tested on North Western. Ry Age v 92 n 16 Apr 16 1932 p 643–8. Two American Steel Foundries' truck designs, embodying new spring arrangement, demonstrate notable improvement in riding qualities; test method and equipment; recording instruments perfected after extensive tests; striking comparison of low actual recorded forces in car equipped with Simplex trucks and high forces in car equipped with conventional trucks at critical speeds.

CARS, PASSENGER

AIR CONDITIONING. Air Conditioning Apparatus to Be Applied to More Baltimore & Ohio Cars. Ry Elec Engr v 23 n 4 Apr 1932 p 81–3. Road plans to equip 78 cars with improved system employing axle drive and new refrigerant; axle-driven generator supplies power; system eliminates brine cooler; plan and elevation showing location of air-conditioning equipment in typical railroad coach.

CASE-HARDENING

STEEL FOR ENGINE PARTS. Oberflaechen

beschaffenheit, Gefuegeausbildung und Festigkeitseigenschaften von Einsatzstaehlen, etc, H. Mueller. Zeit des Bayerischen Revisions-Vereins v 36 n 5, 6 and 7, Mar 15 1932 p 45–7, Mar 31 p 61–5 and Apr 15 p 78–9. Surface properties, structure, and strength of case-hardened steels in their relation to heat treatment; proper heat treatment for case-hardened steels commonly employed in engine construction; influence of cementite structure on decarburization by heating agent.

CAST IRON

TESTING. Wandstaerke und Biegefestigkeit des Gusseisens, H. Jungbluth and P. A. Heller. Archiv fuer das Eisenhuettenwesen v 5 n 10 Apr 1932 p 519–22 (discussion) 522. Wall thickness and bending strength of cast iron; review and evaluation of research on bending strength and deflection with test bars of various dimensions; derivation of formulas for bending calculation with bars of different dimensions; relation between wall thickness, bending coefficient, and position of cast iron in Maurer diagram.

CHIMNEYS

DRAFT. Der Kamin-Kreisprozess, A. Zinzen. Feuerungstechnik v 20 n 3 Mar 15 1932 p 34–6. Chimney circulating process; pressure conditions with gas entry into and emission from chimney; influence of steam on specific gravity of gases and draft in chimney.

COAL CARBONIZATION

LOW-TEMPERATURE. Combined Low Temperature Carbonization and Combustion, D. Brownlie. Eng and Boiler House Rev v 45 n 10 Apr 1932 p 622–5. Review of present situation in operation of large steam-boiler plants; principle of combined low-temperature carbonization and combustion; details of Hereng, Pintsch, and Babcock processes.

COAL HANDLING

EQUIPMENT. Rope - Trolley Coal - Handling Bridge, C. B. Trowbridge. Can Engr v 62 n 15 Apr 12 1932 p 13–15. Description of coal-handling bridge erected at Montreal East for Canada Cement Co., Ltd.; overall length 469 ft; bridge will be equipped with two 5-ton grabs, one opening longitudinally of span and other transversely.

CRANES

DESIGN. Considérations générales sur la construction des grues de port et des grues flottantes, F. Nowak. Manutention Moderne v 6 and 7 n 12, 1, 2 and 3 Dec 1931 p 9–13 Jan 1932 p 11–16 Feb p 12–14 and Mar p 16–18 and 41. General considerations in construction of traveling and floating cranes; stress diagrams and polygons of various types explained.

GANTRY. Gantry Cranes for Hydro-Electric Plants. Power v 75 n 18 May 3 1932 p 648–50. Design and operation of large gantry cranes employed in handling flood and regulating gates on dams, head gates, and stoplogs at power houses, and of others installed for handling equipment of outdoor and semi-outdoor type of plants.

DIES

DESIGN. Tooling for Multi-Slide Machines, C. W. Hinman. Am Mach v 76 n 14 Apr 7 1932 p 462–4. Practical examples of die design for U. S. Tool Co.'s multi-slide blanking and forming machines, making small parts at rate of 125 to 300 per min.

DIESEL ENGINES

AUTOMOTIVE. Considerations of Air Flow in Combustion Chambers of High-Speed Compression-Ignition Engines, J. A. Spanogle and C. S. Moore. Nat Advisory Committee Aeronautics—Tech Notes n 414 Apr 1932 10 p 5 supp plates. Résumé of present status of air-flow investigations and work done to determine direction and velocity of air movement in auxiliary and integral combustion chambers.

Nuovo motore di piccolo alesaggio per autoveicoli e veli-voli, M. Behmann. Rivista Aeronautica v 8 n 1 Jan 1932 p 62–7 9 supp plates. Design and operating principles of new-type small-bore 2-cycle double-acting engine for automobiles and airplanes; bore and stroke $52^1/_2$ by 54 mm; output 35 hp; weight with cooling water 54 kg.

[See also *Airplane Engines*.]

CYLINDER LINERS. Material for Diesel Cylinder Liners, M. E. Greenhow. Power v 75 n 15 Apr 12 1932 p 546–7. Review of latest developments in composition and methods of producing cast iron for various services; tables illustrating chemical analysis of cast iron and alloy cast iron; photomicrographs of grain structure.

Vanadium Iron for Diesel-Engine Liners, G. Myhre. Brit Motor Ship v 12 n 144 Feb 1932 p 430. Details of Norwegian development; properties of Bremanger iron in service; curves showing rate of cylinder-liner wear in motorships with and without vanadium liners.

LUBRICATION. Lubrication of Diesel Engines, H. J. Nicholson. Inst Mar Engrs—Advance Paper v 44 pt 4 mtg Apr 12 1932 11 p. Piston and liner lubrication; 2-stroke-cycle cylinders; bearing-lubrication systems; piston cooling; contamination of oil in circulation; care and treatment of oil in service; centrifugal separator; streamline filter.

SCALE REMOVAL. Removal of Scale From Water Spaces. Engineering v 133 n 3458 Apr 22 1932 p 493–4. In laboratory of Mirrlees, Bickerton, and Day, Stockport, research has been conducted to find rapid and safe method of cleaning out water spaces of Diesel engines; as result, substance, known as Mirrlees inhibitor is being placed on market; consists of dry powder which, when added to hydrochloric acid in correct proportion, greatly reduces action of acid on metal.

SUPERCHARGING. Increasing Output of Diesel Engines by Means of Pressure Charging Blowers Driven by Exhaust Gas Turbines, Oppitz. Brown-Boveri Rev v 19 n 3 Mar–Apr 1932 p 91–6. Use of Brown-Boveri pressure-charging blowers driven by exhaust-gas turbines for raising output of 4-stroke Diesel engines on Buechi system; object of blower is to supply air necessary for pressure-charging engine and also for scavenging cylinder; performance curves.

VIBRATIONS. Elimination of Vibration, R. B. Grey. Diesel Engine Users Assn—Report S 103 mtg Nov 5 1931 p 1–11 and (discussion) 12–31. Methods of reducing vibrations of Diesel engines by proper balancing and mounting on elastically supported foundation; discussion relating to experiences with stationary and marine installations; appendix shows typical vibrograph records.

ELECTRIC WELDING

ARC-WELDING MACHINES. Automatic Carbon Arc Welding. Engineer v 153 n 3981 Apr 29 1932 p 483–4. With object of increasing efficiency and utility of automatic welding plant, extensive research work was carried out in Germany to ascertain to what extent carbon arcs are suitable on plant of this nature; most important part of plant is working head, which holds carbon electrode and maintains arc automatically in suitable condition for work; typical examples.

FITS AND TOLERANCES

SHRINK AND PRESS FITS. Pezzi forzati a caldo o colla pressa nelle costruzioni elettromeccaniche, G. Rebora. Elettrotecnica v 19 n 3 Jan 25 1932 p 68–73. Principal calculations for shrink fits and press fits used in construction of electric machinery; fits of rings on tapering shafts; fits between two concentric rings.

FLIGHT

GLIDING. Soaring Flight: Its Function in Aviation, E. C. G. England. Roy Soc Arts—J v 80 n 4143 Apr 15 1932 p 531–43 (discussion) 543–6. Plea is made for cause of soaring movement in its relationship to rest of aeronautics; four main functions, through which it is aiding substantially progress of aviation, are propaganda, instruction in art of flying, scientific and technical development, and meterological development, each of which is dealt with.

FLOW OF FLUIDS

AROUND OBSTACLES. Mouvement d'un fluide incompressible autour d'un obstacle, D. Riabouchinsky. Académie des Sciences—CR v 194 n 15 Apr 11 1932 p 1215–17. Theoretical mathematical discussion of flow of incompressible fluids around obstacle; mechanical integration of equations of flow.

FREE JETS. Application of Theory of Free Jets, A. Betz and E. Petersohn. Nat Advisory Committee Aeronautics—Tech Memo n 667 Apr 1932 25 p 13 supp plates. Based upon Kirchhoff's theory of free jets, flow through different screen arrangements of flat plates, as chiefly encountered with turbines in cavitation zone is defined; experiments reveal picture of discrepancies between actual flow and theory of discharge of air in air (of water in water without cavitation).

TURBULENT. Transport of Vorticity and Heat Through Fluids in Turbulent Motion, G. I. Taylor, A. Fage and V. M. Falkner. Roy Soc—Proc Series A v 135 n A 828 Apr 1 1932 p 685–702. Diffusion of momentum and temperature and distribution of velocity in wake behind cylindrical obstacle; heat transport; proof that "momentum transport" theory is untrue when motion is confined to two dimensions; extension of "vorticity transport" theory to three dimensions; case of laminar mean flow; experiments on temperature and velocity in wake of heated cylindrical obstacle.

VORTICES. Sur la similitude des vortex, C. Camichel, L. Escande and G. Sabathe. Academie des Sciences—C R v 194 n 12 Mar 21 1932 p 1048–51. Experimental investigation of applicability of principle of similitude to study of vortices; principle of similitude found to apply at least approximately.

FLOW OF GASES

MEASUREMENT. Nomogramme zur Mengenmessung von Gasen und Daempfen, H. Richter. VDI Zeit v 76 n 13 Mar 26 1932 p 320–2. Nomograms for diatomic gases permitting determination of correction factor in flow equations for nozzles; simple equation and graph for determining expansion factor.

FLOW OF LIQUIDS

VISCOUS FLOW. Essai sur le mouvement des liquides visqueux dans une canalisation cylindrique, compte tenu des frottements à la paroi, E. Doucet. Révue Générale de Electricité v 31 n 9 Feb 27 1932 p 270–7. Theoretical mathematical study of flow of viscous liquids in cylindrical channels with special reference to wall friction; study is based on hypothesis according to which loss of energy at wall of channel is function of velocity and of derivative of velocity with respect to normal; dissipation functions.

FURNACES, ELECTRIC

HEAT - TREATING. Elektrische Glueh - und Haerteanlagen, V. Paschkis. VDI Zeit v 76 n 15 Apr 9 1932 p 319–63. Recent developments in field of annealing and hardening furnaces; heating resistance elements; furnace walls; furnaces with horizontal entrance door; design for quick heating and for keeping furnace temperature constant.

FURNACES, HEAT-TREATING

AUTOMATIC CONTROL. New Automatic Hardening Furnace, E. F. Russ. Eng. Progress v 13 n 4 Apr 1932 p 81–2. Layout and operation of furnace manufactured by "Industrie" Elektroofen G.m.b.H., Cologne; hardening salt raised to max temperature of 1650 F by heating from outside by means of resistor; daily output of 5500 lb of small parts.

FURNACES, INDUSTRIAL

PULVERIZED-COAL. Versuche ueber die Verbrennungsvorgaenge in einer Kohlenstaubflamme, H. Schwiedessen. Archiv fuer Waermewirtschaft v 13 n 4 Apr 1932 p 105–6 (discussion) 106. Results of tests on combustion processes in coal-dust flame; speed, temperature, and composition of flue gases; time required for burning; tests were carried out on ingot-heating furnace.

GAS COMPRESSORS

HIGH-PRESSURE. High-Pressure Compressors for Synthetic Ammonia Manufacture. Indus Chemist v 8 n 85 Feb 1932 p 56. Six-stage two-crank compressors, three of which type have been supplied to large synthetic-ammonia factory in Russia, using producer gas as raw material; they are provided with direct steam drive, and are for duty of 350,000 cu ft of free gas per hr; made by A. Borsig G.m.b.H.

GAS ENGINES

IGNITION. Valve Adjustment on Gas Engines, U. A. Patchett. Power v 75 n 17 Apr 26 1932 p 618–20. To obtain best operation from any gas engine it is not only necessary to have correct fuel-air ratio, but this mixture must be taken into cylinder, ignited, and products of combustion exhausted at proper time; timing varies with cylinder ratio and engine speed, and should be determined by test on any particular engine; indicated diagrams illustrating various air-fuel mixtures.

GAS TURBINES

PRESENT STATUS. Lo stato attuale del problema delle turbine a combustione interna, G. Belluzzo. Eletrotecnica v 19 n 5 Feb 15 1932 p 117–121. Present state of internal-combustion-turbine design; problems resulting from necessity of use of high pressures and temperatures; advantages of turbine over reciprocating engine for power plant of more than 250 hp.

GEARS

HELICAL. Modern Double Helical Reduction Gearing. Engineer v 153 n 3978 Apr 8 1932 p 400–1. It is claimed that not a single case of tooth breakage has occurred in gears manufactured by Metropolitan Vickers Co.; double helical type is almost universally used for high-speed work; for gears of this type, involute tooth form has become general; test results on gears to be employed on new Nile Delta land-reclamation scheme of single-reduction type.

RATCHET-TYPE TEETH. Design and Production of Ratchet-Type Teeth, W. Richards. Machy (Lond.) v 39 n 1016 Mar 31 1932 p 845–7.

Determination of relation between included angles of tooth, space, and center angle and methods of producing all possible types of teeth; milling operations on ratchet teeth.

TESTING. Investigation of Performance of Gears, J. H. Hyde, G. A. Tomlinson and G. W. C. Allan. Engineer v 153 n 3979 Apr 15 1932 p 418–20; see editorial comment p 425. Investigations commenced some years ago when Power Plant Co. of West Dayton presented to National Physical Laboratory gear-testing machine with two sets of helical gears; machine utilizes circulation of power principle, and only power losses have to be supplied by driving dynamometer; experiments on efficiency of helical gears; tests on ground spur gears; endurance tests.

Investigation of Performance of Gears, J. H. Hyde, G. A. Tomlinson and G. W. C. Allan. Engineer v 153 n 3980 Apr 22 1932 p 457. Measurement of gear-tooth errors; static tests of strength and elasticity of teeth. Before Instn Automobile Engrs.

GRINDING MACHINES

TUNGSTEN CARBIDE CUTTING TOOLS. Grinding Machine for Widia Tools. Engineering v 133 n 3459 Apr 29 1932 p 511. Machine placed on market by B. R. Rowland and Co is fitted with three wheels, one for roughing, one for finish grinding, and one for polishing.

HAMMERS

PNEUMATIC. Compressed Air Reduces Forge Hammer Cost, F. A. Kolb and R. C. Grimstad. Heat Treating and Forging v 18 n 3 Mar 1932 p 171–3. Replacement of steam by compressed air for hammer operation at Woodings-Verona Tool Works, Verona, Pa., resulting in 50 per cent reduction of cost; detailed comparison of cost data for steam and compressed-air operation.

HARDNESS-TESTING MACHINES

DUROSCOPE. Das Duroskop, O. Schwarz. Zeit fuer Metallkunde v 24 n 4 Apr 1932 p 93–4. Design and applications of the von Leesen hardness tester, manufactured by Rational G.m.b.H., Berlin and known as the Duroscope; design is based on dynamic principles.

HEAT CONDUCTIVITY

SEMI-FLUIDS, MEASUREMENT OF. Measurement of Thermal Conductivity of Semi-Fluids, C. Dannatt. Met-Vickers Gaz v 13 n 229 May 1932 p 247–50. Metropolitan-Vickers Research Department has developed methods for measuring thermal conductivities of electrical insulating materials, in particular materials used in electrical industry, under conditions similar to those under which materials are used.

HEAT-INSULATING MATERIALS

PROPERTIES. Heat Insulation Developed for Every Purpose, B. Townshend and E. R. Williams. Chem & Met Eng v 39 n 4 Apr 1932 p 219–22. Review of developments; temperature range and limit chart of insulating materials; tables giving physical and thermal properties of some heat-insulating materials; variation in conductivity of typical low-temperature, high-temperature, and medium-temperature insulating materials.

HIGH-SPEED STEEL

HEAT TREATMENT. Obtaining Better Results in Hardening High-Speed Steel, W. E. Snow. Machy (N. Y.) v 38 n 8 Apr 1932 p 590–2. Hardening, quenching, and drawing operations, with data on most frequent troubles; cyanide and boracic acid treatments.

HYDRAULIC TRANSMISSION

HELE-SHAW. Hele-Shaw Hydraulic Transmission, J. F. Cooke. Am Soc Naval Engrs—J v 44 n 1 Feb 1932 p 25–9 2 supp plates. Transmission consists of two separate units, designated hydraulic pump and hydraulic motor; pump is Hele-Shaw variable-stroke, variable-discharge, high-pressure pump operated by driving power unit; function is to deliver oil to hydraulic motor at any required pressure and to receive oil back as it is discharged from pump, thus maintaining constant circulation of oil; advantages.

HYDRAULIC TURBINES

LEAKAGE. Controlling Wicket-Gate Leakage on 57,000-Hp. Spier Falls Turbine, R. V. Terry. Power v 75 n 15 Apr 12 1932 p 548–9. Wicket-gate leakage on turbine operating under 81-ft head was kept to less than 0.1 of 1 per cent of unit's rated discharge, by special design for adjusting clearance at ends of gates.

HYDROELECTRIC POWER PLANTS

DESIGN. New Hydraulic Design at Tiger Creek, F. I. Lawson. Elec World v 99 n 14 Apr 2 1932 p 608–10. Recently completed efficiency tests on two 36,000-hp double-overhung impulse waterwheels at Tiger Creek plant of Pacific Gas & Electric Co.; results have created interest in certain new features of hydraulic design; minimizing water disturbance produces high efficiency; method of load rejection and governing features; electrical layout simple.

PUMPED-STORAGE. Note sur l'accumulation d'energie et en particulier sur l'accumulation hydraulique par pompage, M. Clement. Société Industrielle de Mulhouse—Bul v 97 n 9 Nov 1931 p 533–48 1 supp plate; see also abstract in Génie Civil v 52 n 7 Feb 13 1932 p 169–70. Methods of power storage, with special reference to pumped-storage project at Lac Blanc and Lac Noir of Société Hydro-Electrique des Vosges, for utilization of power surplus of Kembs hydroelectric plant in Upper Rhine watershed.

INDUSTRIAL MANAGEMENT

BUDGET CONTROL. Building Budgets for Incentives and Standard Costs, R. E. Case. Factory and Indus Mgmt v 82 n 5 Nov 1931 p 650–2 1 fig. Method of combining budget to serve as basis for standard costs and bonus systems, worked out at East Springfield, Mass., plant of Westinghouse Electric & Manufacturing Co.; by this method hand-outs at high activity and penalties at low activity have been eliminated; method once installed is simple and inexpensive to operate.

Development of Modern Business Budget, D. M. Rogers. J. Accountancy v 53 n 3 Mar 1932 p 186–205. Historical review of business budget development; production budget; budget of sales and distribution costs; management and budget; general conclusions.

Three Budget Compasses Give SKF Industry Smooth Sailing, J. Geschelin. Automotive Industries v 66 n 18 Apr 30 1932 p 648–51. Budget control system of Hess-Bright Mfg. Co., SKF subsidiary in Philadelphia, saved 30 per cent on maintenance-expense account and 15 per cent on indirect-payroll account; illustrations of principal charts and blank forms.

PRODUCTION CONTROL. Administrative Control, R. J. Davis. Taylor Soc—Bul v 17 n 1 Feb 1932 p 6–10 (discussion) 10–17. Operating procedure of central purchasing department of Hills Brothers Co., N. Y.; cost and quality control.

TIME STUDY. Die Menschliche Arbeitsgeschwindigkeit in der Zeitstudie, F. Herr. Werkstattstechnik v 26 n 4 Feb 15 1932 p 66–8. Difference between actual working speed and speed of production; analysis of difficulty of accurate determination of speed; comparison of principal methods of estimating speed.

INTERNAL-COMBUSTION ENGINES

COMBUSTION. Combustion Velocity of Benzine-Benzol-Air Mixtures in High-Speed Internal-Combustion Engines, K. Schnauffer. Nat Advisory Committee Aeronautics—Tech Memo n 668 Apr 1932 17 p 12 supp plates. By cylindrical contact and oscillograph rate of combustion is measured for gas intake velocities of from 30 to 35 m per sec and for velocities within cylinder of from 20 to 25 m per sec; influence of mixture ratios, of turbulence, of compression ratio, and of kind of fuel.

Der Verbrennungsvorgang im Vergasermotor, W. Endres. Forschung auf dem Gebiete des Ingenieurwesens v 3 n 2 Mar/Apr 1932 p 78–83. Study of combustion process in carburetor engines; methods of calculation; influence of combustion-chamber design; tendency to detonation and its relation to combustion-chamber design.

INDICATORS. Piezo-Electric Method of Measuring Pressure Variations in Internal Combustion Engines, H. G. I. Watson and D. A. Keys. Can J Research v 6 n 3 Mar 1932 p 322–31 1 supp plate. Design and operation of piezoelectric pressure gage in which pressures are recorded as displacements of beam of cathode-ray oscillograph; arrangement reduces inertia of gage to minimum; investigation of knocks; specimen records taken on Petter hot-surface engine.

LUBRICATION. Low Viscosity Oils Lubricate Motor More Satisfactorily, C. T. Doman. Oil and Gas J v 30 n 46 Mar 31 1932 p 95. Results of block tests conducted in H. H. Franklin Manufacturing Co's research laboratories show that oil of low viscosity lowers operating temperature of motor and reduces friction losses; tests prove that well-designed air-cooled engine does not run higher oil temperature than water-cooled power plant.

[See also *Airplane Engines; Automobile Engines; Diesel Engines; Gas Engines; Gas Turbines; Oil Engines.*]

LOCOMOTIVES

DIESEL. Locomotive Diesel de 150 ch, pour voie de 0m 60, pour les Chemins de fer du Maroc. Génie Civil v 100 n 16 Apr 16 1932 p 399–400. Design of 150-hp Diesel locomotives for 0.6 m gage built by Schwartzkopff Co.; 6-cyl. 4-cycle MAN engine of 160 by 220 mm bore and stroke, turning at 900 rpm; max tractive effort 6150 kg at 5 km per hr in lowest gear of 5-speed gear box.

DIESEL-ELECTRIC. Diesel-Electric Traction. Elecn v 108 n 2812 Apr 22 1932 p 561–2. Various methods of securing full utilization of oil-engine output; Oerlikon regulation system; characteristics of electric transmission with generator and four traction motors; continuous rating of generator: 490 kw at 620 rpm; one-hour rating of motors: 410 kw at 19 km/h; continuous rating of motors: 430 kw at 31 km/h; description of equipment.

ELECTRIC. Most Powerful Electric Locomotives in World. Ry Engr v 53 n 627 Apr 1932 p 132–8. Details of new 7500 hp 1-Bo-1-Bo-1 + 1-Bo-1-Bo-1 single-phase mixed-traffic locomotives for service on St. Gothard Line, Swiss Federal Railways; desirability of mixed-traffic type; methods of transmission of drive; wheels and frames; braking and starting; traction motors; high-tension control system.

LUBRICATION. Use of Emulsified Oil for Steam Locomotives, S. Matsunawa. Ry Mech Engr v 106 n 4 Apr 1932 p 142–3. Characteristics of emulsified oil, mixture of lime water and cylinder oil, used successfully on Japanese State Railways for lubricating valve chambers and cylinders of locomotives; chemical analysis of carbon and oil deposits taken from piston valves of two locomotives; chart showing average consumption of cylinder oil per 100 locomotive km.

PASSENGER. "Sentinel" Locomotive for Argentine Suburban Services. Ry Gaz v 56 n 14 Apr 1 1932 p 499–500. Buenos Aires Midland Railway have introduced independent Sentinel power units for working improved service of local passenger trains; power supplied by 6-cyl. horizontal single-acting engine with 6-in. bore and 7-in. stroke, arranged for working with steam at 300 lb per sq in. and 650 F to 750 F temperature; principal dimensions; details of coaches.

LUBRICATING OILS

MICROSCOPIC EXAMINATION. Eine Mikroskopische Untersuchung von Destillaten mineralischer Oele, F. Schwarz. Berg- und Huettenmaennisches Jahrbuch v 80 n 1 Mar 15 1932 p 19–23. Microscopic analysis of distillates of mineral oils; with aid of microscope, it is possible to determine thickness of film of lubricating oils and heavy distillates at temperatures up to 280 C; from curves obtained, lubricating value in given temperature range, paraffin content, gas formation, and, probably formation of highly molecular polymeric compounds, can be determined.

SYNTHETIC. Synthesis of Lubricating Oils From Coal and Its Gaseous Products, A. W. Nash. Petroleum World (Lond.) v 29 n 379 Apr 1932 p 103–7. Review of known methods for producing synthetic lubricating oils; hydrogenation; polymerization of olefines; volatilization; method of carbonization of coal and treatment of distillation products by these synthetic processes. Before Third Int Conference Bituminous Coal.

TESTING. Lubricants and Their Relation to Engine Tests, F. J. Slee. Chem Age v 26 n 668 Apr 16 1932 p 342. History of laboratory testing of lubricating oils; significance of tests, such as specific gravity, flash point, viscosity, and saponifiable matter; selection of lubricants for special purposes; limitations of specification; principal physical tests; compounding of steam-cylinder oils. Before Soc Chem Industry.

LUBRICATION

FRICTION COEFFICIENTS. Ricerche sperimentali sull'attrito fra corpi semilubrificati, N. Nerli. Ingegnere v 5 n 12 Dec 1931 p 830–8. Experimental investigation of different types of oils and bearing metals with regard to performance under conditions of imperfect lubrication.

MACHINE TOOLS

PNEUMATIC. Hilfsvorschuebe an Werkzeugmaschinen, K. Deuring. Werkstattstechnik v 26 n 7 Apr 1 1932 p 142–5. Design and operating characteristics of pneumatic feed mechanisms with hydraulic control using oil.

REPLACEMENT. Berechnung der Wirtschaftlichkeit einer Mehrspindelbohrmaschine, R. Reder. Maschinenbau v 11 n 6 Mar 17 1932 p 120–1. Example of calculating efficiency of multiple-spindle drilling machine with particular regard to problem of amortization and distribution of overhead charges in relation to output.

WELDED STRUCTURES FOR. Welding Facilitates Use of Stiffest Shapes for Machine Tool Loads, E. Chapman. Iron Age v 129 n 17 Apr 28 1932 p 972–4. Stiffness, and particularly torsional stiffness, so necessary in machine tools.

provided by completely closed and tubular structural sections; may be fabricated in every conceivable form and with least amount of metal by means of welding; consideration of vibration problem. Before Am Soc Mech Engrs.

MACHINERY

RUBBER MOUNTINGS. Rubber — New Material in Machine Design. Machy (NY) v 38 n 8 Apr 1932 p 561–5. Developments in application of rubber mountings to absorb vibration illustrated by designs of Lord Mfg. Co., Erie, Pa.; diagram showing relation of load to deflection.

MALLEABLE-IRON CASTINGS

MACHINABILITY. Investigation of Methods to Determine Machinability of Malleable Iron Castings, O. W. Boston. Am Soc Testing Matls—Proc v 31 pt 2 1931 p 388–418 and (discussion) 419–21. Results of investigation for Malleable Iron Research Institute; results of laboratory experiments designed especially for this purpose.

METALS

COLD WORKING. Metal Rolling in Mass Production, J. R. Cornelius. Am Mach v 76 n 17 Apr 28 1932 p 556–8. Discussion of article previously indexed from issue of Jan 7 1932; possibilities and limitations of hot and cold rolling; reference to Mannesmann process.

CUTTING—SINKING AND REAMING. Die Zerspanungsverfahren des Senkens und Reibens, A. Wallichs and H. Schallbroch. VDI Zeit v 76 n 7 Feb 13 1932 p 161–2. Results of experimental investigation of cutting forces in sinking and reaming operations.

DEFORMATION. Recent Researches on Plasticity, Lodé, G. I. Taylor and H. Quinney. Metallurgist (Supp to Engineer) Mar 25 1932 p 34–7. Orientation of principal axes of stress and strain; comparison between von Mises' first hypothesis for condition for commencement of plastic distortion; relationship between ratios of principal shear stresses and ratios of corresponding principal strains.

FLOW. Einige Messungen ueber den Fliessdruck von Metallen in tiefen Temperaturen, R. Holm and W. Meissner. Zeit fuer Physik v 74 n 11–12 Mar 11 1932 p 736–9. Test set-up for measurement of flow pressure at low temperatures according to ball pressure method, and determination of contact surface; results for gold, platinum, silver, lead, tin, and copper.

FLUIDITY. Facteurs principaux de la coulabilité des métaux purs, A. Portevin and O. Bastien. Académie des Sciences—C R v 194 n 7 Feb 15 1932 p 599–601. Principal factors in fluidity of pure metals; investigations of aluminum, zinc, antimony, cadmium, lead, and tin; it is concluded that specific heat, latent heat of solidification, and melting point are as important as viscosity.

HARDENING. Hardness Changed by Magnetism, E. G. Herbert. Metal Progress v 21 n 4 Apr 1932 p 52–6. Research to discover most favorable conditions for magnetic hardening led to discovery that rotary magnetic treatment set going progressive change of hardness completed after many hours; test results for different types of steel and non-ferrous metals.

PROPERTIES. Limitations of Our Fundamental Knowledge of Properties of Metals, F. O. Clements. Metal Industry (Lond.) v 40 n 12 and 13 Mar 18 1932 p 323–4 and Mar 25 p 353–4. Problems in different fields of applied metallurgy illustrate need for further research.

New Method for Measuring Mechanical Properties of Metals, L. H. Hounsfield. Soc Chem Industry—Chem Eng Group—Advance Paper mtg Feb 12 1932 16 p. Correlation of physical properties of principal ferrous and nonferrous metals and alloys, including precious metals; design and operation of minature tensile machine with "autographic" recording device; erroneous impressions concerning small specimens; procedure of making notched-bar impact tests and bending tests.

TEMPERATURE EFFECT. High-Temperature Characteristics of Metals Revealed by Bending, H. Scott. Am Soc Testing Matls—Proc v 31 pt 2 1931 p 129–56. Curvature produced in initially flat strip by heating it while bent to known curvature is easily measured after release at room temperature; as curvature change can be easily measured with high sensitivity and testing equipment is simple, it offers attractive means for investigating plastic behavior of metals at elevated temperatures.

MOLDING MACHINES

GERMAN. Recent Developments in Molding Machines in Germany, H. Illies. Iron and Steel Industry v 5 n 6 Mar 1932 p 233–7. Design and operating principles of representative types; shockless jolt-molding machine by Badische Maschinenfabrik; shockless jolt-squeeze molding machine made by Gustav Zimmermann, Duesseldorf-Rath; "Prewerma" jolt molding machine of Gesellschaft fuer Giesserei-Industrie, Cologne; squeezing and ramming machine by Herring & Sohn, Milspe i. W.; pneumatic jolt and squeeze molding machine of Vogel & Schemmann A. G., Kabel i. W.

NON-FERROUS METALS

EXTRUSION. Extrusion of Metals, R. Genders. Metals Industry (Lond.) v 40 n 13 Mar 25 1932 p 345–9. Examples illustrate use of soft metals with improved high-speed machinery, and adaptation of process to harder metals and alloys at high temperatures; metallurgical studies of process; materials include copper, brasses, aluminum, and its alloys, magnesium alloys, aluminum bronze, tin bronze, and copper-nickel alloys.

Kraftbedarf und Fliessvorgaenge beim Stangenpressen, W. Eisbein. Zeit fuer Metallkunde v 24 n 4 Apr 1932 p 79–84. Power requirements and flow movement in extruding bars; cold extrusion of tin and lead in laboratory and hot extrusion of hard brass (58 per cent copper, 2 per cent lead) and copper on 1000-ton press; flow is determined by new method; equation of power requirements is developed; structures of extruded hard-brass bars are shown.

OIL ENGINES

FUEL INJECTION. New Fuel Injection System. Engineer v 153 n 3979 Apr 15 1932 p 420–2. New fuel pump, entirely British in its origin and design, invented by A. F. Evans and developed jointly with S. Hopkins, styled E-H fuel pump; description of pump and its new principle of operation. Technical report on engine tests made with pump at Wembley is appended.

PHOTO-CONTROL

INDUSTRIAL APPLICATIONS. Photocells in Shop, I. Saxl. Am Mach v 76 n 14 Apr 7 1932 p 456–9. Schematic diagram for control of power processes with aid of photocells; heat-treating temperatures controlled by beam of light reflected from mirror galvanometer; electronic color selection; combustion control.

NEW TYPE. Empfindliche Lichtsteuerung mittels Spiegelmembran, C. Mueller. Zeit fuer Technische Physik v 13 n 4 1932 p 171–80. Experiments with new type of photo-control employing reflecting diaphragm of 0.001 to 0.002 mm thickness, and which is highly sensitive to all factors involved in use of picture transmission, infra-red wave telephony, and oscillography.

PHOTOELASTICITY

ENGINEERING APPLICATIONS. Polarised Light and Its Applications to Engineering, E. G. Coker. Metallurgia v 5 n 30 Apr 1932 p 189–94. Loaded transparent plate models of parts of machines are examined in polarized light and show internal stresses as they occur in actual members; how these experiments provide solutions to problems in some cases where theoretical analysis fails. Before Instn Mech Engrs.

PIPE

HEAT TRANSMISSION. Die Waermeabgabe eines horizontalen geheizten Rohres an Kaltes Wasser bei natuerlicher Konvektion, G. Ackermann. Forschung auf dem Gebiete des Ingenieurwesens v 3 n 1 Jan–Feb 1932 p 42–50. Experimental investigation of heat transfer of horizontally heated pipe to cold stationary water; representation of heat-transfer coefficient as function of temperature of wall and surrounding water.

PLASTICS

ASBESTOS - RESIN. Asbest - Kunstharz - Massen, V.D.I. Belani. Kunstoffe v 22 n 2 Feb 1932 p 30–1. Manufacture and machining of asbestos synthetic resin masses, known as "A-K" pastes, used in modern kitchen utensils, in construction of containers, filter presses, fans, and acid pumps, in automobile, and airplane accessories, etc.; product is development of bakelite pressed masses.

PRESSES

HYDRAULIC. Hydraulic Presses for Extruding Non-Ferrous Metals, E. Pfann. Eng Progress v 13 n 4 Apr 1932 p 94–6. Design and operation of different types of large extruding presses built by Schloemann Aktiengesellschaft, Duesseldorf, for manufacture of tubing, rods, sections, wire, and strips.

PLATE-FOLDING. Folding, Rounding, and Box Forming Machine. Engineer v 153 n 3978 Apr 8 1932 p 404. Machine designed by James Bennie and Sons to facilitate flanging and bending of steel plates prior to electric welding; makers claim that it is of particular utility in manufacture of switchgear cases, transformers, cars, safes, tanks, etc.

PUMPS, CENTRIFUGAL

MANOMETRIC LIFT. Die manometrische Foerderhoehe bei Kreiselpumpen, H. Kissinger. Chemische Fabrik v 5 n 9 Mar 3 1932 p 65–7. Manometric lift of centrifugal pumps; data on design, operation, and characteristics.

PUNCH PRESSES

POWER REQUIREMENTS. Energy Requirements and Motor Selection for Power Presses, W. M. Evarts. Metal Stampings v 5 n 1, 2, and 3 Jan 1932 p 15–18 and 38 Feb p 121–4 and 138 and Mar p 189–92 and 205–6. Jan: Capacities of presses and calculation of energy requirements for shearing and drawing operations. Feb: Requirements for ironing, forging, and sizing, embossing and coining, stamping and extrusion. Mar: Energy losses due to friction, counterbalances, drawing cushions, as well as spring in press frames under load.

RAIL MOTOR CARS

OIL-ELECTRIC. Oil-Electric Car in Mixed Train Service, R. J. O'Brien. Ry Age v 29 n 15 Apr 9 1932 p 602–3. Brief review of six months' operation of 400-hp, single-power-plant car purchased from Westinghouse Electric and Manufacturing Co. and operated in North Dakota and Manitoba by Great Northern.

REFRIGERATION

VACUUM. Vacuum Refrigerating Systems. Ice and Refrig v 82 n 4 Apr 1932 p 245–6. Details of new vacuum refrigerating system designed for maintaining water at low temperatures where supply of steam is available; operated by principle of "flash evaporation;" specially adapted for plants having steam power and supply of condensing water.

RUBBER

SHOCK ABSORBENT, USE AS. Symposium on Rubber. Am Soc Testing Matls—Advance papers for mtg Mar 9 1932 116 p. Flexing of Rubber Products, E. G. Kimmich; Use of Rubber for Absorption of Shock Vibration, R. K. Lee; Some Factors in Deterioration of Rubber When Exposed to Frictional Relations With Other Materials, V. A. Cosler.

SAWS, METAL-WORKING

HYDRAULIC DRIVE. Neue Kaltkreissaegen mit hydraulischem Vorschub und hydraulischer Einspannung, Kessner. Werkzeugmaschine v 36 n 4 Feb 29 1932 p 61–3. Design and operating principles of circular cold saw with hydraulic feed and work-holding device built by Gebrueder Heller, Nuertingen, Wuertt.

MANUFACTURE. "Composite" Steel Works of James Neill & Co. (Sheffield), Ltd. Machy Market v 1639 Apr 1 1932 p 283–6. Production methods and equipment used in manufacture of "Eclipse" hacksaw blades; hacksaw tooth-pitch table; allowances for various cutting surfaces.

SHEET-METAL WORKING

DRAWING. Untersuchungen ueber die Pruefung der Tiefziehfaehigkeit von Feinblechen, F. Eisenkolb. Stahl und Eisen v 52 n 15 Apr 14 1932 p 357–64. Investigations of methods for testing deep-drawing capacity of sheet metals; results of numerous tests show that it is mainly degree of strain hardening which is determined by chemical composition and annealing; it is concluded that present testing methods do not adequately indicate qualities of deep-drawn sheets.

STEAM

RADIATION. Messung der Gesamtstrahlung des Wasserdampfes bei Temperaturen bis 1000° C, E. Schmidt. Forschung auf dem Gebiete des Ingenieurwesens v 3 n 2 Mar/Apr 1932 p 57–70. Measurement of total radiation of steam at temperatures up to 1000 C; rotation-oscillation spectrum of steam; temperature field in steam jet; radiation tests and their evaluation; application of test results to radiation exchange of water vapor with surfaces of any given temperature; radiation of air-vapor mixture and of higher-pressure steam.

STEAM CONDENSERS

CONTROL. Ermittlung von Kondensatorundichtheiten durch Leitfaehigkeitsmessung, H. Reichelt. Waerme v 55 n 16 Apr 16 1932 p 253–6 (discussion) 256. Determination of leakiness in condensers by conductivity measurement; example is given of calculation of cooling water in condensate and salt content in condensing steam; measuring methods and instruments.

SURFACE. Economics of Surface Condenser Selection, J. H. Smith. Power v 75 n 19 May 10

1932 p 691–6. Design and application of surface condensers has become so specialized that free exchange of knowledge, between manufacturer and purchaser of all factors affecting proposed installation is essential if best interests are to be served; article stresses such exchange of information and emphasizes importance of economic analysis.

STEAM GENERATION

ELECTRIC. Design of Electric Steam Generators, B. A. Malkin. Can Engr v 62 n 12 Mar 22 1932 p 11–13 and 36. Economical method of utilizing surplus energy from hydroelectric power stations; boiler built by Canadian General Electric Co. is of single-tank type, essential difference between it and Kaelin boiler being that it is divided into two compartments, upper and lower; equipment is illustrated and described.

STEAM PIPE LINES

INSULATION. Die Bestimmung der Wirtschaftlichsten isolierstaerke bei Rohrleitungen, C. Fabry. Waerme v 55 n 10 Mar 5 1932 p 163–4. Determination of most economical insulating thickness of pipe lines; derivation of formula; new price lists; influence of heat-conductivity and heat-transfer coefficients; use of charts and tables.

UNDERGROUND. Der Waermeverlust von Rohrleitungen im Erdreich, I. S. Cammerer. Archiv fuer Waermewirtschaft v 13 n 2 Feb 1932 p 29–33 (discussion) 33–4. Investigation of heat loss of pipe lines in soils, carried out on two insulated and two non-insulated underground pipes; earth moisture; temperature fields; heat loss of non-insulated lines; heat conductivity of earth.

STEAM POWER PLANTS

COAL HANDLING. Manutention des charbons à la centrale de Vitry-Sud, J. Vennin. Revue Industrielle v 62 n 2273 Apr 1932 p 196–207. Coal-handling equipment of Vitry-Sud plant of L'Union d'Electricite; plant burns 3000 tons of fuel per day, which is supplied by rail and ship via Seine.

PEAK LOADS. Einfluss des Spitzenausgleiches auf den Waermewirkungsgrad von Grundlastwerken, H. Schult. Waerme v 55 n 16 Apr 16 1932 p 257–9. Influence of load equalization on thermal efficiency of base-load plants; attempt is made to determine quantitatively improvement in thermal efficiency in central stations through use of heat storage for peak-load equalization.

PROGRESS IN. Kraft und Dampf, O. Berner. Waerme v 55 n 10 Mar 5 1932 p 145–8 (discussion) 148. Report on progress in power and steam engineering; relations between large central stations and industrial power plants in light of latest technical developments; combined heating and power plants; long-distance heating; furnaces and boilers.

PULVERIZED - COAL. Die maschinentechnischen Erweiterungsbauten des Grosskraftwerks "Gersteinwerk," H. Roentsch. Zeit des Bayerischen Revisions-Vereins v 36 n 3, 4, 5, 6 and 7, 15 1932 p 24–6 Feb 29 p 32–4 Mar 15 p 39–42 Mar 31 p 58–60 and Apr 15 p 76–7. Improvements in machinery of "Gersteinwerk" steam power plant Dortmund, Germany; coal-handling and pulverizing plant; boilers are vertical-tube, triple-drum type; SSW-Roeder turbines coupled to SSW generators, designed for output of 24,000 kw at 3000 rpm; feedwater treatment.

STEAM TURBINES

BLADES. Versuche zur Verbesserung des Wirkungsgrades von Dampfturbinenschaufeln, F. Burghauser. Forschung auf dem Gebiete des Ingenieurwesens v 3 n 2 Mar/Apr 1932 p 83–6. Results of tests for improving efficiency of steam-turbine blades; in author's opinion decrease in efficiency is due to usual high condensation of steam on hollow side of blade, and he concludes that much wider blades than those now in use would give better efficiency; formula for average condensation pressure is set up; suggestions for economic design of steam turbines.

DESIGN. Brown-Boveri Steam Turbines—II, J. S. Brown. Power Engr v 27 n 312 Mar 1932 p 108–13. Design and constructional details of two and three-cyl turbines manufactured by Brown, Boveri & Co.; sectional diagrams illustrating details; high-pressure sets; comparison of thermal efficiencies of 1-, 2- and 3-cyl turbines at 3000 rpm.

Dimensionering av Aangturbiner med Hjaelp av Varaktighetsdiagram, G. F. Heikel. Teknisk Tidskrift v 62 n 12 Mar 19 1932 p 33–5. Graphical representation of relations between size and steam consumption of turbines with particular regard to determination of time of obsolescence.

TEMPERATURE DISTRIBUTION IN. Temperature Distribution in Steam Turbine Casings, E. Brown. Engineering v 133 n 3456 Apr 8 1932 p 425. With reference to article previously indexed from Mar 11 1931 issue of same journal, under heading of Turbo-Generators—Great Britain, temperature curves are presented taken 1 mm below surface of bore both at flange and at adjacent plain wall; method introduced by Brown, Boveri, for preventing loss of heat from metal masses during recurrent periods of non-operation by supplying auxiliary heat.

STEEL

ALLOY. See *Alloy Steels.*

FATIGUE. Steigerung der Dauerfestigkeit bei Rundstaeben mit Querbohrungen, A. Thum and H. Oschatz. Forschung auf dem Gebiete des Ingenieurwesens v 3 n 2 Mar/Apr 1932 p 87–93 (discussion) 93. Report from Materials Testing Institute of Darmstadt Institute of Technology on increasing fatigue resistance in round bars with transverse holes; influence of transverse holes of various sizes on fatigue strength; methods of increasing fatigue resistance; practical conclusions based on tests of soft ingot steel.

HIGH-SPEED. See *High-Speed Steel.*

SHEET—AGING. Aging of Sheet Steel. Metallurgist (Supp to Engineer) Apr 29 1932 p 62–4. While it has been abundantly demonstrated that appreciable changes may take place in physical properties of sheet steel when stored at room temperatures, causes giving rise to these changes have not been definitely established; phenomenon appears to be one of aging, but until substances giving rise to this effect are definitely identified, suggestion cannot be unreservedly accepted.

HEAT TREATMENT. Manufacture and Heat Treatment of Sheet and Strip Steels—I and II, E. F. Davis. Fuels and Furnaces v 10 n 2 and 3 Feb 1932 p 113–8 and Mar p 205–8 and 20. Feb: Review of salient points in manufacture of sheet and strip steel: rolling, annealing, normalizing, inspection and testing, defects, and kinds of steel used. Mar: Box annealing of sheet and strip steel; normalizing; pickling.

HARDNESS, TESTING. Unterlagen fuer die Pruefung und Walzhaertenstaffelung von kaltgewalztem kohlenstoffarmen Bandstahl, A. Pomp and F. Winterhoff. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung zu Duesseldorf (Abhandlung 197) v 14 n 2 1932 p 11–24; see also Stahl und Eisen v 52 n 16 Apr 21 1932 p 396. Bases for testing and roll-hardness grading of cold-rolled low-carbon strip steel; investigations for establishing uniform denomination of different states of hardness as basis for classification into grades of hardness.

PLASTICITY. Plasticity as Applied to Steel Products, A. Nadai. Engrs' Soc West Pa—Proc v 48 n 3 Mar 1932 p 65–72 and (discussion) 72–9. Investigation of stress distribution and slip phenomena with particular regard to cold or hot rolling, forging, and pressing operations; use of photoelastic methods.

STEEL CASTINGS

ANNEALING. Annealing of Steel Castings, W. R. D. Jones and P. F. Foster. S Wales Inst Engrs—Proc v 48 n 1 Apr 7 1932 p 43–62 and (discussion) 63–6. Effect, on mechanical and other properties, of annealing medium-carbon steel castings for varying lengths of time; annealing procedure; chemical analysis of representative samples taken from each casting; results of mechanical tests; appendix on application of X-ray crystal analysis.

STOKERS

CHAIN-GRATE. Progress in Art of Solid Fuel Burning, W. D. Wylde. Eng and Boiler House Rev v 45 n 10 Apr 1932 p 664–6. Design and operating details of stoker which has been evolved from advantages of non-traveling and traveling grate types; diagrams illustration design features.

OVERFEED. Versuchsergebnisse bei Verfeuerung geringwertigerer Brennstoffe auf Kaskadenueberschubrosten, J. J. Ehemann. Brennstoff und Waermewirtschaft v 14 n 4 Apr 1932 61–5. Experimental results in firing of low-grade fuels on cascade overfeed stokers; tests were carried out mostly by boiler-inspection societies or licensed authorities, and are believed to be reliable.

STRESSES

ANALYSIS. Polarisationsoptische Spannungsuntersuchungen an unsymmetrischen Stabecken und an Doppelhaken, L. Kettenacker. Forschung auf dem Gebiete des Ingenieurwesen v 3 n 2 Mar/Apr 1932 p 71–7 (discussion) 78. Polarization-optical-stress analysis of asymmetrical corners of bars and of double-loaded hooks; results of tests on asymmetrical corners stressed by single load or moment; symmetrically loaded double hooks.

SUPERHEATERS

COMPENSATING. Compensating Superheaters, P. W. Thompson. Power v 75 n 17 Apr 26 1932 p 620. Brief details of superheater design that will deliver steam at practically constant temperature over wide range of boiler rating; developed by Superheater Co. to be installed in type W Stirling boilers in Trenton Channel station of Detroit Edison Co.; section through boiler showing superheater arrangement.

CONTINUOUS OPERATION. Hohe Dampftemperaturen—Einige Erfahrungen und Betrachtungen, F. Marguerre. VDI Zeit v 76 n 12 Mar 19 1932 p 287–92. Experiences in continuous operation of superheaters and flange joints with particular regard to effects of high temperatures (470 C); lowering of permissible stress values due to creep and fatigue; comparison of thermal efficiency for high- and low-pressure operation at high temperatures.

THERMODYNAMICS

LOW-TEMPERATURE HEAT. Theoretical Consideration of Value of Low-Temperature Heat, W. C. Johnson, Jr. Gen Elec Rev v 35 n 4 Apr 1932 p 227–9. Study of heat for average engineer; attempt is made to bring out something of rather well-known, but often misunderstood, theoretical background of heat processes; heat-cycle analogies; minimizing waste of high-grade and low-grade energies; by-product power.

MIXED-VAPOR POWER PRODUCTION. Mixed Vapour Power Production, T. Barratt. Steam Engr v 1 n 7 Apr 1932 p 306–7. Principles of thermodynamics; efficiency of "mixed vapor" engine; calculations pertaining to "mixed vapors and power machines;" engine trials.

My Mixed Vapour Effect Is Natural Effect, A. Irinyi. Steam Engr v 1 n 7 Apr 1932 p 310–12. General review of developments together with letters received by author pertaining to mixed-vapor properties; preliminary test results.

TORSIONMETERS

NEW TYPES. Measurement of Angular Strains During Twisting of Cylindrical Specimens, C. E. Larard. Engineering v 133 n 3456 Apr 8 1932 p 417–18. Two instruments designed by author for experimental work on behavior of ductile material during twisting to destruction: high-precision torsionmeter for measuring very small increments of angular strain; handy laboratory torsionmeter for measuring angles of torsion through both elastic and plastic stages during testing of small- and moderate-diameter specimens.

TUBES

COLD-SWAGING MACHINE. Reduces $2^1/_4$-in. Tubing to $1^1/_4$-in. at Rate of 9 Ft a Minute. Iron Age v 129 n 11 Mar 17 1932 p 676–7; see also Mech Eng v 54 n 5 May 1932 p 367. Machine for reducing diameters and wall thicknesses of tubing, developed by Pipe & Tube Bending Corp of America, Newark, N. J.; in one pass through machine, tube of $2^1/_4$ in. outside diam with wall thickness of $^1/_4$ in. has been reduced to $1^1/_4$ in. outside diam with wall thickness of 0.09 in.; reciprocating crosshead contains two rolls which perform combined cold swaging-forging operation on length of tubes.

HEAT TRANSMISSION. Die Waermeabgabe eines Drahtes oder Rohres an einen senkrecht zur Achse stroemenden Gas- oder Fluessigkeitsstrom, J. Ulsamer. Forschung auf dem Gebiete des Ingenieurwesens v 3 n 2 Mar/Apr 1932 p 94–8. Heat emission of wire or tube to gas or liquid stream perpendicular to axis; review of earlier research; evaluation of recent tests with air and with liquids; comparison with older theoretical results.

WATER VAPOR

HEAT OF VAPORIZATION. Heat of Vaporization of Water at 50°, 70°, and 90° C, E. F. Flock and D. C. Ginnings. U S Bur Standards—J Research v 8 n 3 Mar 1932 p 321–4. Values of heat of vaporization of water at 50, 70, and 90 C, have been determined as 2382.6, 2333.6, and 2283.4 international joules per gram; results were obtained subsequent to publication of detailed report on calorimetric determinations of thermal properties of saturated water and steam.

WELDS

X-RAY ANALYSIS. X-Ray Diffraction Patterns. Welding Engr v 17 n 4 Apr 1932 p 35–7. Relations between crystal structure and stresses in welds and adjacent metal; effects of annealing and cold working.

X-Rays in Welding Industry, R. A. Stephen. Engineer v 153 n 3978 Apr 8 1932 p 393–4. As result of development of shockproof X-ray tubes in Philips Research Laboratories, new "Metalix" industrial X-ray unit has been introduced, which combines absolute electrical safety with self-protection of Metalix tube against unwanted radiation; work on welded vessels which has been carried out with this unit.